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Monthly Bulletin of the International Railway Congress Association

(English Edition)

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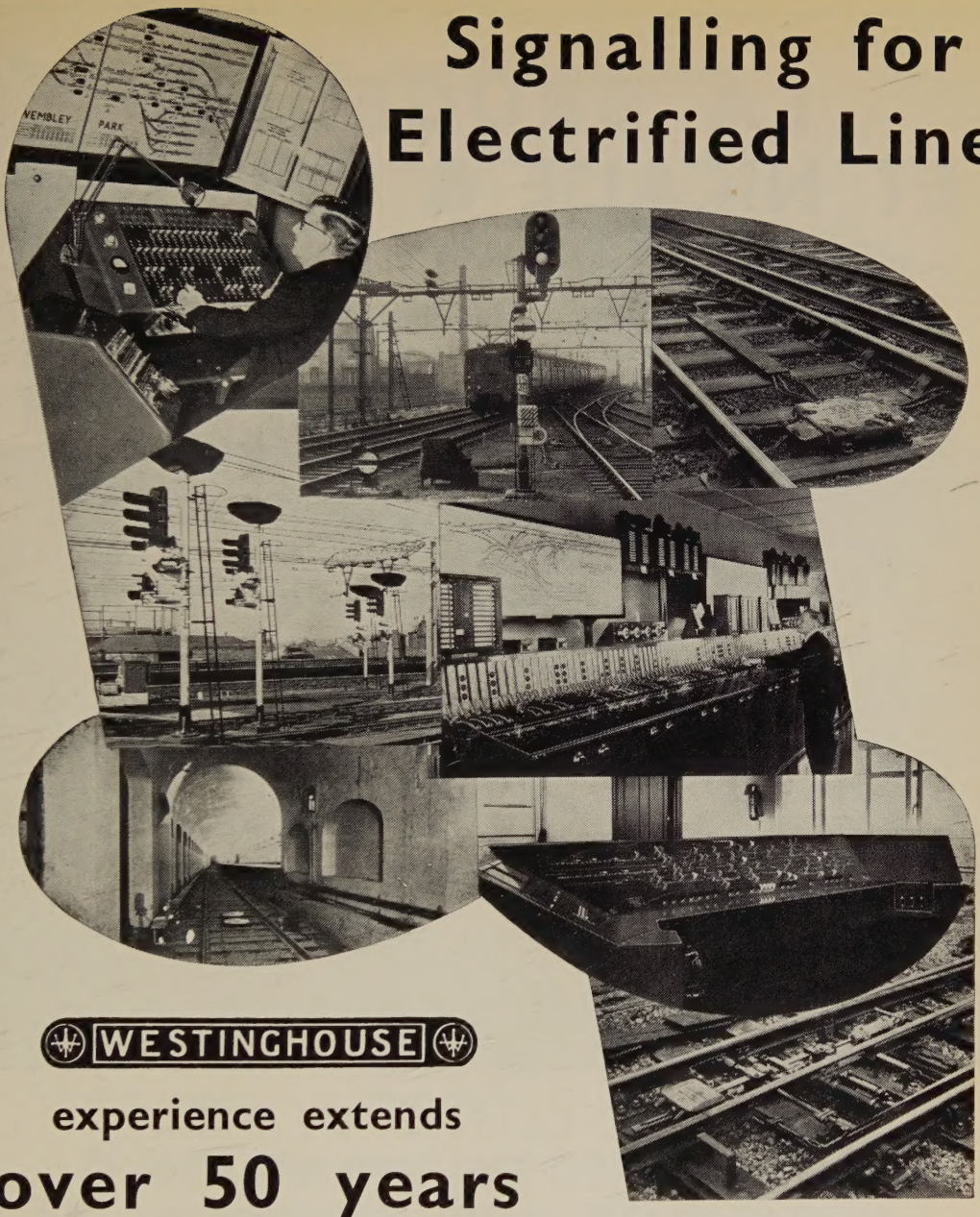

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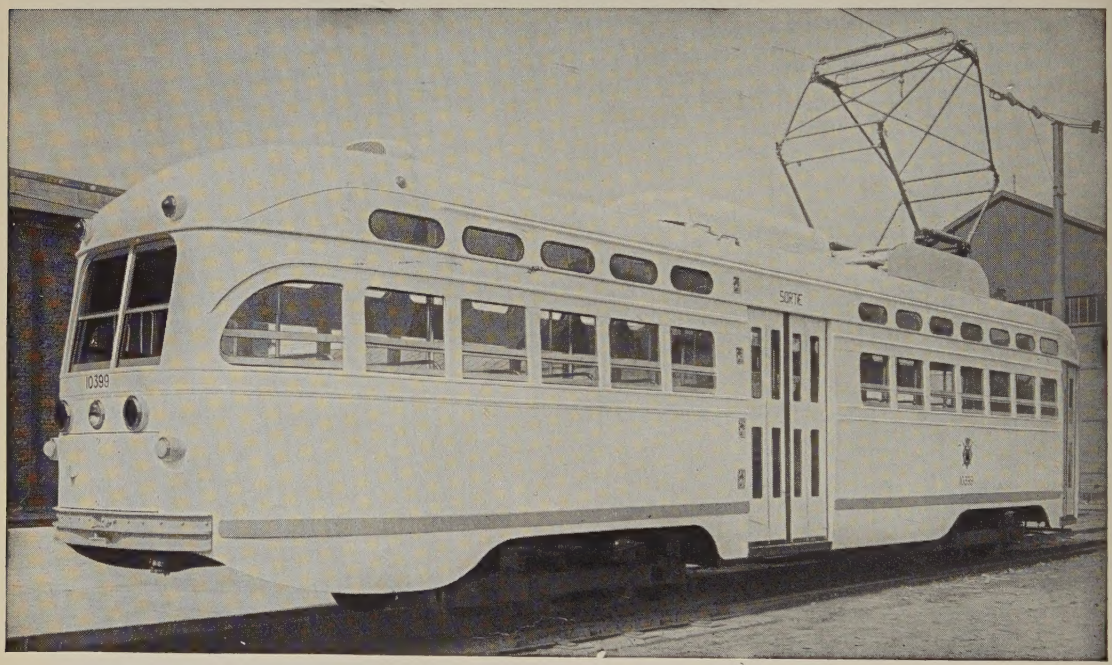

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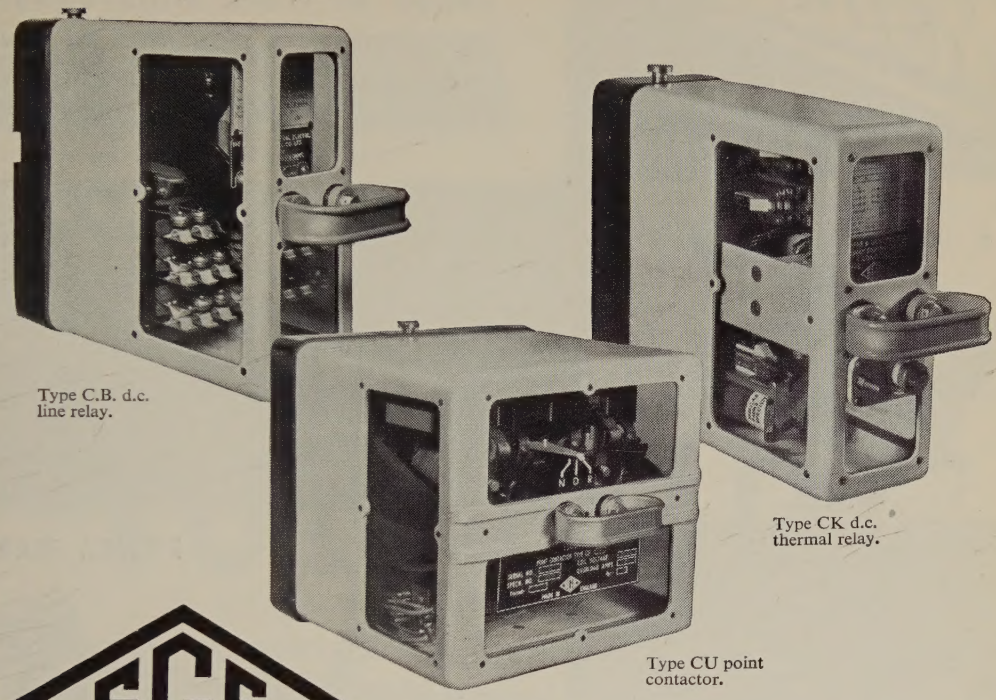

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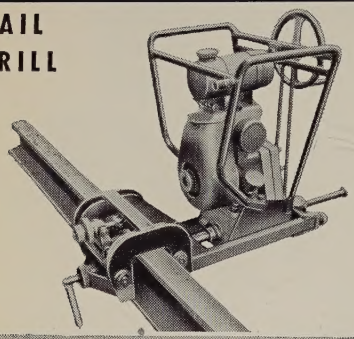

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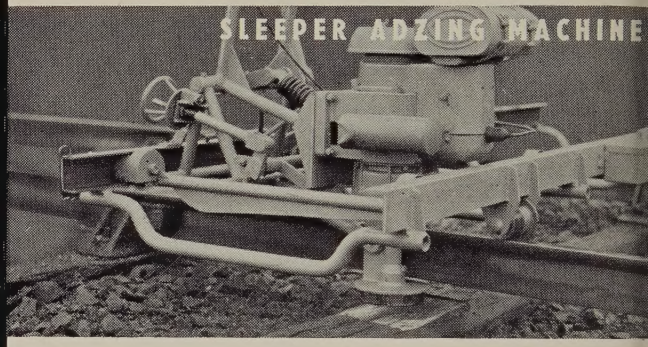
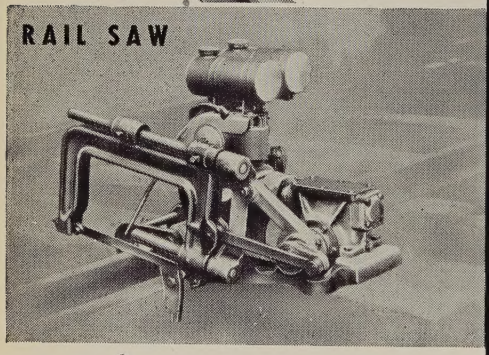


RAIL SAW



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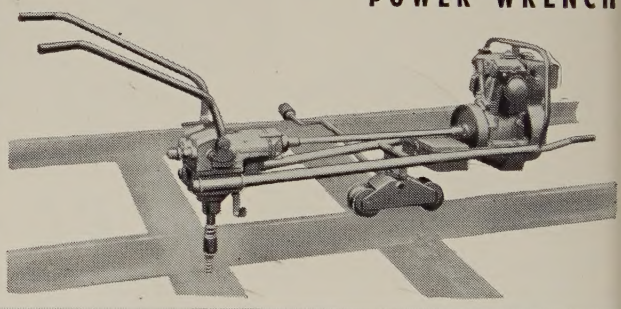

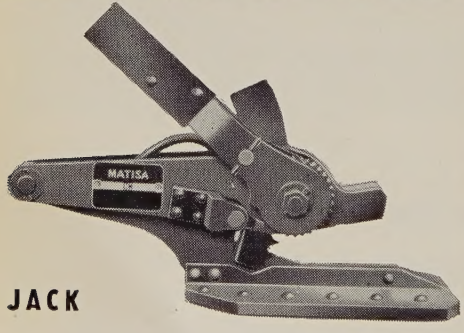

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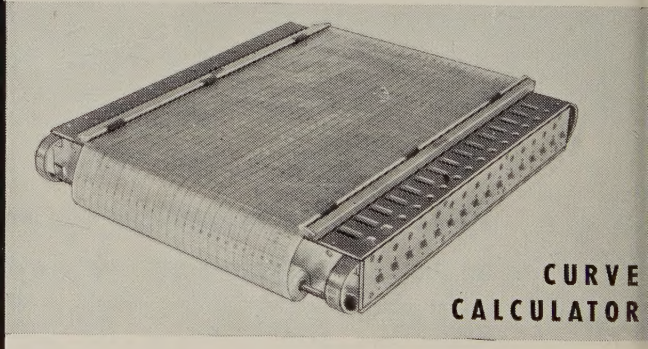

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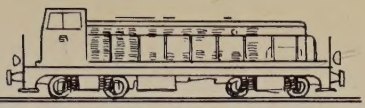

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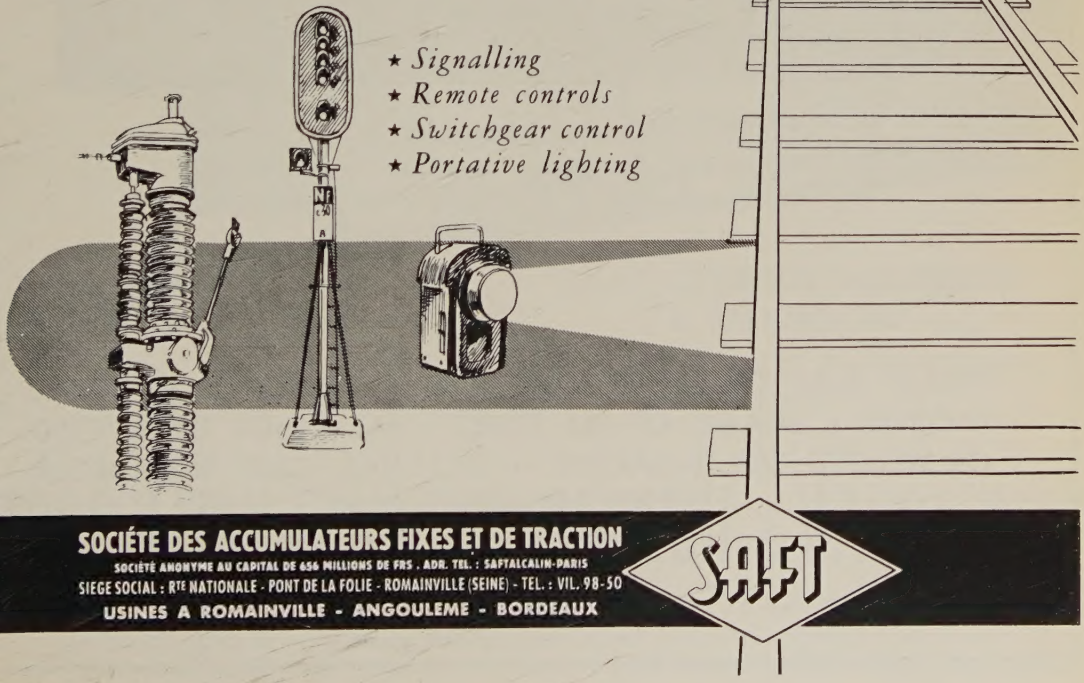

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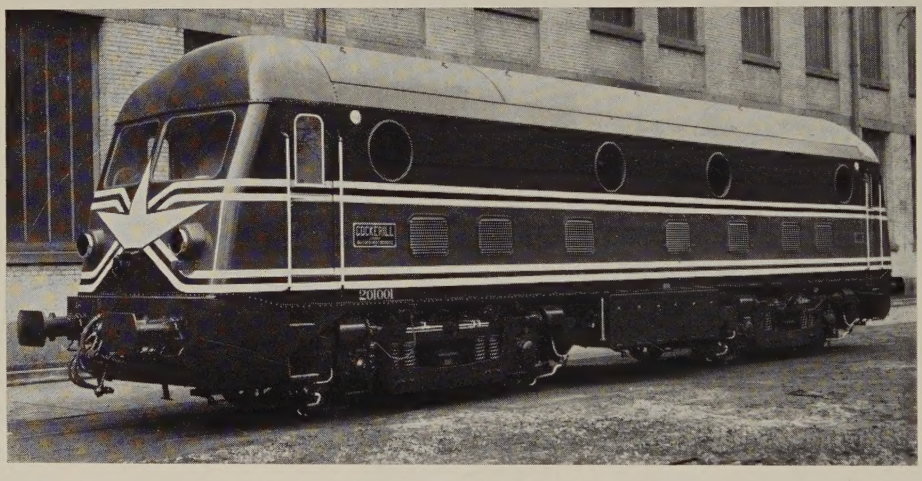

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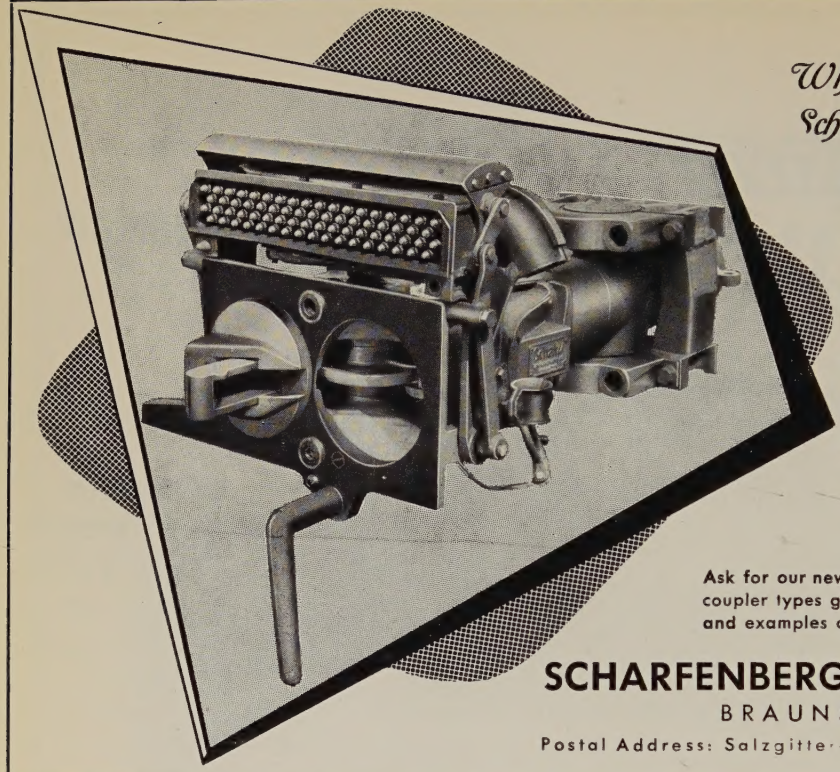

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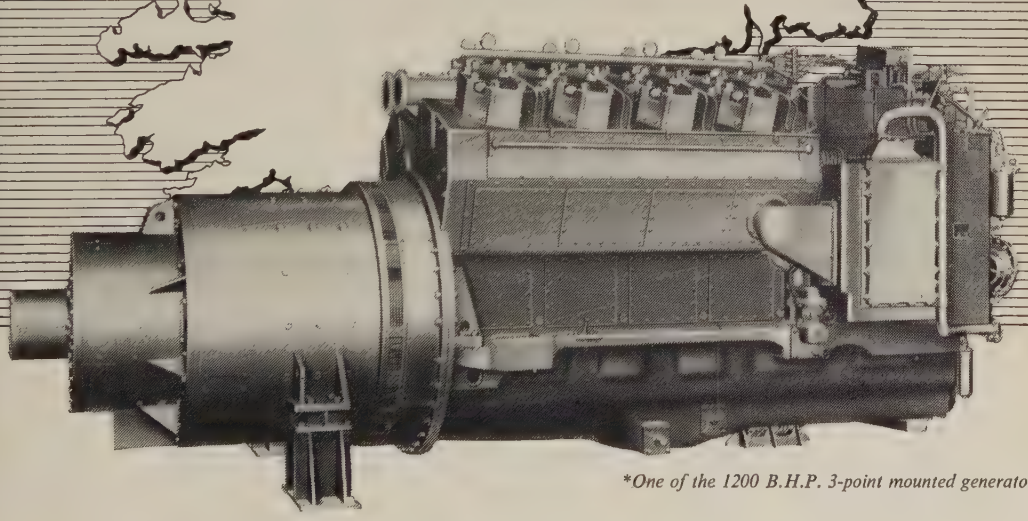

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Alphabetical Index of Advertisers

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Siemens and General Electric Railway Signal Co. Ltd.	III	Signalling equipment.
S.K.F. (Société Belge des Roulements à Billes)	—	Axleboxes.
Superheater Company (The)	—	Superheaters for locomotives.
United Steel Companies, Ltd. (The)	—	Railway materials.
Voith, J.M. (G. m. b. H.)	—	Turbo-transmissions.
Westinghouse Brake & Signal Co., Ltd.	I	Railway signalling. Brakes.

Bulletin of the International Railway Congress Association

CONTENTS OF THE NUMBER FOR DECEMBER 1955

1955 625 .212 (493)
Bull. of the Int. Ry. Congr. Ass., No. 12, December, p. 851.
MEYER (E.). — **Contribution to the detection of axle flaws by the ultrasonics method.** (3 500 words & figs.)

1955 625 .28
Bull. of the Int. Ry. Congr. Ass., No. 12, December, p. 861.
International Days on Railway Traction (Liège, April 1955). (700 words & figs.)

1955 656 .222 (44)
Bull. of the Int. Ry. Congr. Ass., No. 12, December, p. 865.
MERMIER (St.). — **Revision of the operating conditions on the lines of average importance of the South-Eastern Region in order to speed up the fast trains.** (5 400 words, tables & figs.)

1955 625 .28 (43)
Bull. of the Int. Ry. Congr. Ass., No. 12, December, p. 880.
FLEMMING (F.). — **The problems of the changing of traction structure.** (5 000 words & tables.)

1955 656 .1 (44) & 656 .211 .5 (44)
Bull. of the Int. Ry. Congr. Ass., No. 12, December, p. 891.
BOUTIN (P.). — **Connecting road services at Caen.** (700 words, tables & figs.)

1955 625 .28 (73)
Bull. of the Int. Ry. Congr. Ass., No. 12, December, p. 896.
Passenger stock developments in U.S.A. (700 words & figs.)

1955 621 .431 .72 (73) & 625 .28 (73)
Bull. of the Int. Ry. Congr. Ass., No. 12, December, p. 900.
G. M. building complete high speed train. (900 words & figs.)

1955 656 .254 (73)
Bull. of the Int. Ry. Congr. Ass., No. 12, December, p. 904.
DUNN (J. A.). — **More efficient railroading... Modern signaling = Fewer tracks.** (2 000 words & figs.)

1955 385 (02
Bull. of the Int. Ry. Congr. Ass., No. 12, December, p. 910.
NEW BOOKS AND PUBLICATIONS : **Directory of Railway Officials and Year Book 1955-1956.** (300 words.)

1955 385 (09 (45)
Bull. of the Int. Ry. Congr. Ass., No. 12, December, p. 910.
NEW BOOKS AND PUBLICATIONS : **Ingegneria Ferroviaria, Maggio-Giugno 1955. Fascicolo dedicato al Cinquantenario delle Ferrovie dello Stato.** *(Ingegneria Ferroviaria, May-June 1955, Number devoted to the Fiftieth anniversary of the State Railways.)* (500 words.)

1955 669 .71
Bull. of the Int. Ry. Congr. Ass., No. 12, December, p. 911.
NEW BOOKS AND PUBLICATIONS : **Congrès International de l'Aluminium (Paris, 1954). Rapports et discussions.** *(The International Aluminium Congress, Paris 1954. Reports and discussions.)* (500 words.)

MONTHLY BULLETIN

OF THE

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(ENGLISH EDITION)

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CONTENTS OF THE NUMBER FOR DECEMBER 1955.

CONTENTS	Page.
I. **Contribution to the detection of axle flaws by the ultrasonics method,** by E. MEYER	851
II. **International Days on Railway Traction (Liège, April 1955)**	861
III. **Revision of the operating conditions on the lines of average importance of the South-Eastern Region in order to speed up the fast trains,** by Stéphane MERMIER.	865
IV. **The problems of the changing of traction structure,** by Dipl.-Ing. F. FLEMMING . . .	880
V. **Connecting road services at Caen,** by P. BOUTIN	891
VI. **Passenger stock developments in U.S.A.**	896
VII. **G. M. building complete high speed train**	900
VIII. **More efficient railroading... Modern signaling = Fewer tracks,** by John A. DUNN.	904

CONTENTS *(continued)*.	Page.
IX. New Books and Publications :	
Directory of Railway Officials and Year Book 1955-1956	910
Ingegneria Ferroviaria, Maggio-Giugno 1955. Fascicolo dedicato al cinquantenario delle Ferrovie dello Stato. *(Ingegneria Ferroviaria, May-June 1955. Number devoted to the Fiftieth anniversary of the State Railways.)*	910
Congrès International de l'Aluminium (Paris, 1954). Rapports et discussions. *(The International Aluminium Congress, Paris 1954. Reports and discussions.)*	911
X. Monthly Bibliography of Railways	91
XI. Analytical Table of Articles according to the decimal classification . . .	1 to 9
XII. Contents of the 32nd year of the English edition	I to VI

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An edition in French is also published.

Vol. XXXII. — No. 12. December 1955.

BULLETIN
OF THE
INTERNATIONAL RAILWAY CONGRESS
ASSOCIATION
(ENGLISH EDITION

[625 .212 (493)]

Contribution to the detection of axle flaws by the ultrasonics method,

by E. MEYER,

Ingénieur principal au Service du Matériel et des Achats de la Société Nationale des Chemins de fer belges.

1. Introduction.

The wheel centres of rolling stock are fixed on the axles. Owing to the fixing stresses and metal fatigue, surface flaws will appear in the axles during the years of their service life.

These flaws which are located in the inner part of the axle seat (fig. 1) slowly extend towards the axle centre and over the whole periphery of the axle seat.

When the flaw has reached one-quarter or one-third of the original cross-section of the metal, the axle will suddenly break.

Axles of goods wagons very often fall victim to such cracks. Axle fractures of passenger coaches are very rarely encountered on the Belgian Railways.

Let us consider the axle of a goods wagon weighing 35 tons with load. The load on each axle box is $\frac{35}{4} = 8.75$ tons ignoring the weight of the wheels. An axle of a bogie vehicle weighing 55 t when loaded is subjected to much smaller stresses. The corresponding load per axle box is merely $\frac{55}{8} = 6.875$ tons.

This simple calculation does not take into account the fact that a passenger coach is incomparably better sprung than the body of an ordinary goods wagon so that, all other things being equal, the life of a wagon axle will be much shorter than that of a coach axle.

The fracture of a goods wagon axle will generally occur on the open section, particularly when passing through a curve or over points, so that the consequent derailment will often be spectacular.

It is therefore important to discover the flaws in good time.

The problem confronting the Belgian National Railways is a major one since the number of their wagons amounts to 80 000. The number of axles to be periodically inspected is high.

Moreover, the cracks appear at a point which is inaccessible except when the wheels are taken off, because the flaw is located in a zone within 1 centimetre from the inner edge of the wheel centre.

For the inspection of the axle seat, two methods are available :

1) the magnetic method;
2) the ultrasonics method.

2. Magnetic method.

For the inspection of an axle seat by means of the magnetic method, it is necessary to remove the wheel centre and then to subject the axle to an intensive electromagnetic field directed along the axle centre line whilst pouring, over the accessible part of the axle seat, a liquid containing iron filings in suspension.

5) a can containing the liquid;
6) powerful artificial lighting.

The training of the person entrusted with the inspection of the axles is very simple, as the formation of the sinuous brown lines marking out the cracks can be recognized immediately.

The work of the operator can, incidentally, be checked by random tests, by occasionally breaking the suspect axles.

The magnetic method does not call for any machine which would not be available in a major wagon repair shop. The only machine obviously of a special type, viz. that destined to produce the

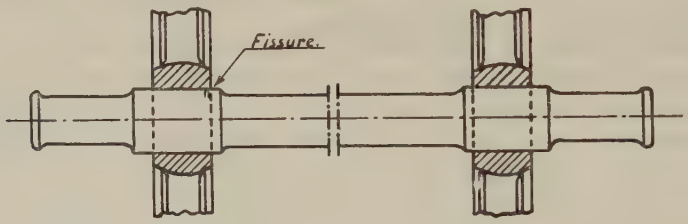


Fig. 1.
Fissure = flaw.

The interruption of the electro-magnetic field at the spot of surface flaws is marked by a coloured line, caused by the accumulation of iron filings.

The apparatus to be used for this purpose comprises :

1) a press for the removal of the wheel centres;
2) the apparatus required for the production of a powerful electromagnetic field;
3) a wheel press for the re-fixing of the wheel centres;
4) handling gear for the handling of axles and wheels;

electromagnetic field, is very simply obtained by using an old rivet heater, the secondary low tension windings of which are short-circuited by a cable with large cross-section, making a dozen turns around the axle to be tested.

The magnetic method has, however, some serious drawbacks :

1) The method is slow; it is difficult to exceed a rate of 8 axle tests per hour;
2) The method requires a labour force of about six men and is therefore expensive;
3) The method can only be used in large workshops where powerful presses are available;

4) The inspection of all the axles of the railway system would entail major handling costs : lifting of all vehicles, replacement of the axles, despatch of the axles to a major workshop, and return of the axles found to be in order.

The inspection of axles is therefore at present limited to those types of axles with which the greatest number of fractures has been experienced. But it is desirable to find a simpler and faster method which can also be used in minor workshops during the periodic lifting of the wagons, and which can therefore be applied to all axles.

The magnetic method, which has stood the test and which has permitted the elimination of a great number of fractured axles, must not be abandoned, as it will serve to confirm the results obtained by a simpler and less expensive method.

The Belgian National Railways decided to carry out experiments with ultrasonics equipment.

3. Detection by ultrasonics.

Very roughly, the ultrasonics detection method might be compared to detection by radar. This over-simplified picture permits an appreciation of the way in which cracks are detected.

Use is made of the fact that the cracks run normal to the axle centre line. If a cylindrical test piece is subjected to an alternating mechanical wave beamed as a very narrow bundle, the propagation of the wave follows the laws of optics.

This wave passes through the piece, is reflected at the end of the cylinder, and returns towards its source.

If the piece is cracked, the wave will be reflected prematurely.

The solution of the problem consists in distinguishing between the two echos : the wave reflected at the end of the test piece, and the wave reflected at a flaw.

We shall briefly examine the apparatus required for the production of the wave, for the detection of the reflected waves, and for the elimination of the waves reflected at the end of the test piece.

a) *Producing the waves.*

A high-frequency oscillator supplies an electric wave. This wave leads to an inductance coil attuned to a given frequency, say 2 megacycles. A piezoelectric quartz is connected with the coil. The quartz has the remarkable property of vibrating mechanically in accordance with the electrical frequency applied to it, provided that it is cut along an axis of symmetry.

Thus, by applying the quartz to the workpiece to be tested, the latter is exposed to a mechanical wave.

Detecting reflected waves.

The quartz also possesses the inverse property of being able to convert into an electric wave a mechanical wave applied to it. It is thus possible to conceive a quartz receiver picking up the reflected mechanical waves and transforming them into electric waves.

In practice, the quartz generator and quartz receiver are, with numerous equipments, combined in one, it being sufficient to block the reception when the emission takes place. This is done in the following way :

The waves are not emitted continuously but in intermittent wave trains. During the emission, the reception can be blocked. For this purpose, it is sufficient to provide a device preventing the amplification of

the waves received when the transmitter is working.

b) *Measuring device.*

A tube with widened bottom part, the base of which is lined with fluorescent material, serves as a luminous screen. The permanence of the signals on the fluorescent material is such that the observer can simultaneously distinguish the different luminous signals.

The wave initially emitted is represented by a luminous line which we shall call *entrance signal.* The wave reflected at the end of the workpiece is represented by a luminous line which we shall call *rear wall echo.* The wave reflected by a flaw is represented by a luminous line known as *flaw echo.*

Rear wall echo and flaw echo are distinguished on the luminous screen with the aid of a device similar to that used in cathode ray oscillographs.

By using a convenient scale, it is possible to use the entire fluorescent screen between the entrance signal and the rear wall echo. There is proportionality between the actual distances and the distances measured on the screen.

If :

L = the length of the workpiece;

l = the distance between the entrance signal and the rear wall echo;

A = the actual distance between the surface to which the quartz is applied, and the zone of the flaw;

a = the distance between entrance signal and flaw echo,

one obtains the relation :

$$\frac{L}{l} = \frac{A}{a}$$

where L, l and a are known or can be measured, so that A can be determined.

c) *Application of this method to wagon axles.*

The principles outlined above serve for the detection of flaws in workpieces which have a uniform or nearly uniform cross-section. Unfortunately, the axles of wagons do not belong to that category.

There is thus reason to fear two contingencies :

a) to be unable to detect existing defects;

b) to detect non-existing defects.

Such fictitious defects are commonly known as « virtual flaws ».

Let us consider the case of figure 2.

The wave emitted by the quartz cannot reach the flaw so that there is no wave reflection, and the existing flaw cannot be detected.

Let us now consider the case of figure 3.

The wave emitted by the quartz penetrates in a slightly oblique direction and enters the wheel centre where it is reflected and returns towards the receiver.

The wave thus reflected will give the illusion of a virtual flaw. The operator will not be able to distinguish between the echo of a real flaw and a virtual flaw because the distances covered by the waves are practically equal.

For the detection of flaws in wagon axles, it is therefore necessary to apply a less simple method which eliminates both sources of error. This method which is believed to have been invented by Dr. KRAUTKRÄMER and which is used, on a large scale, by the German Federal Railways has also been tried out by the Belgian National Railways.

It has not been possible to apply an exact replica of the German method to

the testing of Belgian axles because the latter are of very varied origin (Belgian, British, German, American, etc.); the shapes of the axles as well as their finish differ. Moreover, the German axles are lathe-finished whereas certain Belgian axles are left unfinished over the section comprised between the two axle seats.

In the German method which has served as a basis for our tests, use is made of pulsators placed obliquely on the part of the axle comprised between the two wheel centres.

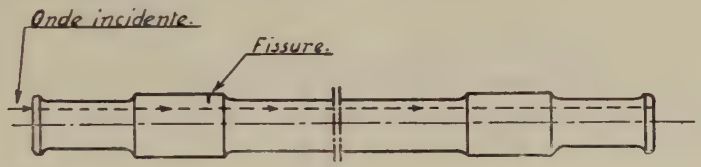


Fig. 2.
Onde incidente = i ncident wave.

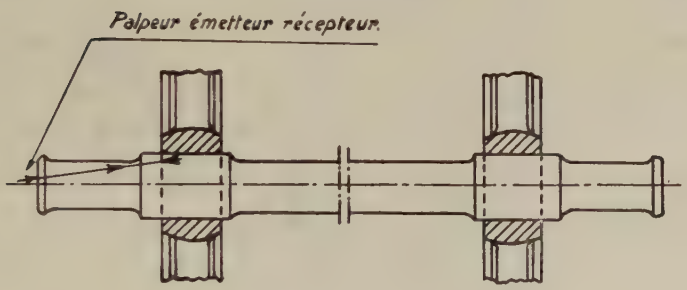


Fig. 3.
Palpeur émetteur récepteur = generating and receiving pulsator.

d) *Principle of flaw detection by means of oblique pulsators.*

With the method of detecting flaws by means of oblique pulsators, the bundle of waves is directed on the flaw in such a way that a reflection echo is obtained. If the bundle of waves does not encounter a flaw, it runs through the whole length of the piece but does not, in this case, call forth a rear wall echo because, in view of the long distance covered by the oblique rays which are reflected many times, the rear wall echo will no longer appear on the screen.

The oblique rays are obtained in the following way : the quartz is placed in an oblique prism made of plastics. In order to avoid the propagation of the longitudinal waves and to retain the transverse waves only, angles of incidence exceeding 30° will be chosen.

Figure 4 shows the path of the transverse wave in the case of a non-defective axle, whilst figure 5 shows the formation of an echo-causing reflected wave due to a flaw.

It will be seen from figure 5 that the flaw will be detected when the pulsator is placed at the end of the diameter opposite to the flaw.

It will also be seen that the centre line of the pulsator is situated at a distance l of the flaw, and that l is given by the relation :

$$l = D \tan \alpha$$

It is possible to prepare templates for different axle diameters which will enable the operator to avoid all risk of error because the axle must obviously be scanned along a circumference situated at a distance l from the axle seat.

The geometrical shape of the pulsator merely has the appearance of an oblique prism. The supporting surface on the

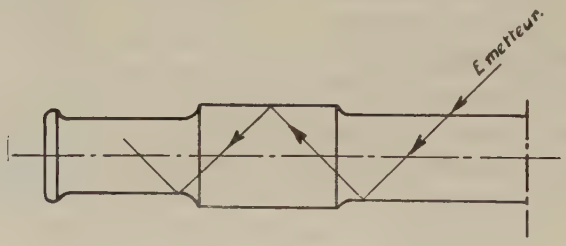


Fig. 4.
Emetteur = transmitter.

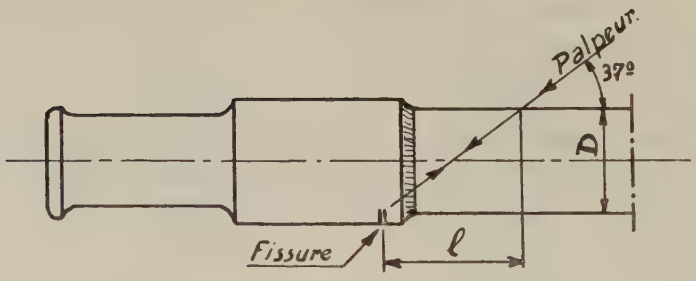


Fig. 5.
Palpeur = pulsator.

where α represents the angle at which the pulsator is set.

With the aid of this fundamental relation it is possible to find the point where the pulsator should be applied.

The angle α has been chosen as 37°, tan α being 0.75. The distance l can thus be calculated without great difficulty as it is sufficient to take 3/4 of the axle diameter.

axle is not level but is curved to match the surface of the axle. The contact between pulsator and axle is further improved by the use of a thick type of oil which tends to improve the wave transmission.

Dr. KRAUTKRÄMER's apparatus presents an appearance as shown in figure 6.

The various knobs have the following functions :

Knob 1 — serves to switch in the apparatus and to set the diagram.

Knob 2 — serves to adjust the entrance signal so that it coincides with a mark on the screen.

Knob 3 — serves to adjust the rear wall echo so that it coincides with a mark on the screen.

Knob 4 — serves to magnify successively any of the signals received so that the different echos can be analyzed in detail.

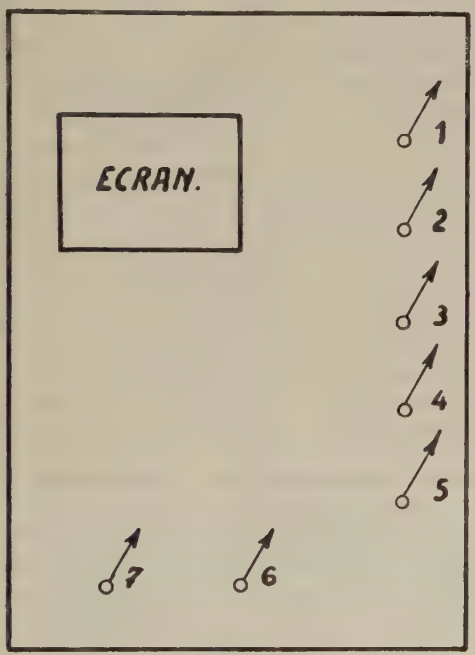


Fig. 6.
Ecran = screen.

Knob 5 — serves to regulate the power of emission.

Knob 6 — permits a choice of the maximum depth to be scanned; when testing a workpiece which is longer than the distance chosen, a rear wall echo is no longer obtained.

The apparatus can be set for the following depths : 100 mm, 250 mm, 1 000 mm, 2 500 mm, 5 000 mm.

Knob 7 — provides a 10-step regulation of the amplification.

Knobs 3 and 4 are not used for the detection by means of obliquely placed pulsators.

Knob 5 is set for a minimum power.

Knob 6 is set for a depth of 250 mm so that the rear wall echo is eliminated.

Knob 7 will be placed in different positions.

The actual tests.

The apparatus has been installed at Cuesmes Central Workshop which is also equipped with magnetic testing apparatus so that the results indicated by the operator can be checked on the spot.

The axles with which the operator is confronted have not yet been submitted to the magnetic test so as not to influence the demonstration.

It was found from the outset that the apparatus indicated the smallest defects.

One of the first axles tested was marked as suspect but was declared as satisfactory as a result of the magnetic test. On closer examination of the axle seat at the spot indicated by the operator, one found a small defect probably due to an old hammer blow.

The apparatus became too sensitive, and it was necessary to reduce its sensitivity to avoid the risk of rejecting axles which were still satisfactory.

No. of test	Flaw echo in %	Corresponding amplification	Diagnosis	Actual result Depth of the flaw in mm
1	85 30	10 4	very small flaws 2 to 3 cm long	axle in good condition
2	30	10	small flaw	very small flaw
3	—	—	good	good
4	90 30	10 5	cracked	crack of 3.5 mm
5	100 30	5 2	cracked over 2/3 of circumference	crack of 4 to 5 mm
6	30	4	cracked over 3/4 of circumference	crack of 2 mm
7	30	5.5	strictly localised defect	axle to be kept in service
8	—	—	good	good
9	—	—	good	good
10	30	6	local defect	axle in good condition
11	30	6	local defect	axle in good condition
12	30	3	defect extending over nearly the whole periphery	deep crack of 4.5 mm

After various trials, the following method was adopted :

Knob 5 is set for minimum power. Knob 7 is initially set for maximum amplification (No. 10 position), which is subsequently reduced so as to reduce the height of the flaw echo to one-third of the height of the screen.

The position of the amplifier for that height is noted. After magnetic testing, the axle is then broken and the depth of the flaw measured on the samples collected.

It is thus possible to lay down a first provisional empiric rule : Only those axles must be considered as unsatisfactory for which the necessary amplification is less than 6 if the height of the flaw echo is adjusted to one-third of the screen height, and provided that the echo is not confined to a very small part of the periphery.

With this rule, entirely empiric though it was, it has been possible to carry out the tests in a very encouraging way. A new series of six axles was subjected to ultra-

sonics testing, magnetic testing and determination of the depth of the flaws after breaking the axle.

The results of these tests are summarized in the following table, where the flaw echo is expressed in % of the height of the screen.

The « actual result » is the depth of the flaw measured after breaking the axle, after the magnetic method has confirmed the presence of the flaw.

Conclusions.

The earlier conclusions arrived at prior to these tests have been confirmed :

1) An axle passed as good by the KRAUTKRÄMER's apparatus is, in fact, good (Tests Nos. 3, 8 and 9).
2) Echos obtained with an amplification greater than 5 can be ignored (Tests Nos 2, 7, 10 and 11).
3) Local echos, i.e. echos which are only obtained from a single position of the pulsator, can be ignored even if they are obtained by means of small amplification (Tests Nos. 1 and 10).
4) Echos which can be obtained over a major part of the periphery without the need for strong amplification are indicative of a serious defect (Tests Nos. 4, 5, 6 and 12).
5) There is a certain relation between the depth of the flaw and the small degree of amplification required to obtain an echo of given height.

	Amplification	*Height*
Test No. 4	5	3.5
Test No. 5	2	4
Test No. 6	4	2
Test No. 12	3	4.5

This relation is not immediately apparent from the reading of the table, because the roughness of the surface plays a great part. For example, the axle of test No. 4 was extremely rough, and it is certain that the amplification coefficient would have been smaller if the surface of the axle had been smoother.

It would not be possible to determine the numerical relation between the depth of the flaw and the amplification volume merely on the basis of these few tests since, apart from the roughness of the axle periphery, the nature of the metal and especially the age of the metal are liable to play a certain part in the absorption of ultrasonic waves.

However, the results found so far are very encouraging and it has been decided to continue the test until it has been possible to determine more accurate rules with a view to training the operators destined to operate these apparatus.

e) *Organisation of axle testing.*

If the further tests confirm the first results obtained up to now, axle testing will be organised in the following way, in a number of line-side workshops.

When a wagon is lifted, the axles are moved, without removing the wheels, to a test stand equipped with an axle lifting jack able to turn horizontally, and with an ultrasonics detector.

The lifting jack, fitted with a Vee block, received the axle in a lowered position. The jack is then raised so that a labourer can rapidly clean the two sections to be tested. This cleaning is facilitated by the fact that the axle can freely rotate on the Vee block.

The operator tests one axle seat, turns

the axle by 180° so that he needs not change place, and then tests the other axle seat. Those axles which are declared suspect are then sent to the Central Workshop for magnetic testing and, where appropriate, for the measurement of the flaw.

If the axle has to be sent to the Central Workshop, the operator will fill in a card stating the height of the echos, the degree of amplification used etc. so as to facilitate the determination of relations between the depth of the flaw and the importance of the echos.

In addition, a certain number of axles declared as satisfactory by the operator will be counterchecked by magnetic testing so as to keep him on the alert.

It will no doubt be possible to reduce, to a very appreciable degree, the number of serious accidents caused by broken axles on the open line.

[625 .28 (493)]

International Days on Railway Traction (Liège, April 1955).

On the occasion of the International Mining, Metallurgy and Mechanics Fair, which was held at Liège during April of this year, the « Association des Ingénieurs sortis de l'Ecole de Liège (A. I. Lg.) » organised study days devoted to traction on the railway.

The honorary chairman for these meetings was Mr. M. De Vos, General Manager of the Belgian National Railways.

The choice of subject was most fortunate as the Belgian Railways in modernising their methods of traction, had just put into service the first units of an important series of Diesel-locomotives, and, on the other hand, are carrying out the electrification of other main arteries of their system.

The BB 122 electric locomotive of the S. N. C. B.

Fourteen reports, devoted to the two main systems of modern traction (Diesel and electric), to the latest developments in steam traction and to gas turbine locomotives were presented by the most competent personalities designated to

the A. I. Lg tribune by European railways and manufacturers taking part in the modernisation of the motor stock of the S. N. C. B.

These days were therefore most successful and attracted great interest.

The July 1955 issue of the *Revue Universelle des Mines* is devoted entirely thereto.

Taken as a whole for each of the techniques in question, these communications may be summed up as follows :

DIESEL TRACTION.

For shunting services, the Diesel locomotive is indisputably better than any other method of traction : it saves power, labour and maintenance costs.

In the sphere of railcars, where 125 to 1 000 HP engines are used, the fight between the various methods of transmission (electric, mechanical and hydraulic) is at the base of the new techniques : torque converters and hydraulic make and break.

Amongst recent innovations, mention must be made in particular of the horizontal engine (which can be mounted under the floor of the vehicle), as well as air cooled engines.

The BB 201 Diesel-electric locomotive of the S. N. C. B.

Imitating the example of the U. S. A., various European countries are putting into service Diesel locomotives for the train services.

The manufacturers are designing slow or fast running engines, two or four strokes. The manufacture of all components, from the gearbox to the piston rings, is constantly being improved.

In spite of its complication, electrical

transmission, which has now been fully perfected, is being used more and more.

It would however be premature to assume that all problems have been solved in terms of European conditions, and that it is already possible to define the traffic limits within which Diesel traction is economically superior to its closest competitor, electric traction.

use of nose suspended engines, and an increase of the installed power.

Parallel development is taking place with single phase 16 2/3 Hz and in those countries using this system, various new types of elastic drive have recently been designed.

Various countries are showing very great interest in single phase 50 Hz traction. The electrifications carried out in the Belgian Congo and in France have gone past the experimental stage and are making use of two different techniques: direct motors and motors fed by ignitrons or by rotary transformer groups.

The CC 202 Diesel-electric locomotive of the S. N. C. B.

ELECTRIC TRACTION.

Three systems are widely used in Europe; a fourth system (single phase 50 Hz) is, it appears, likely to develop on a large scale.

The evolution of the D.C. engine has been characterised by increased speeds, its coefficient of flexibility (ability to work various kinds of services), the development of automatic starting systems, a wider

The mechanical parts of the motors, no matter to what system they belong, show certain new forms in terms of the precise programme of a technical and

economic character : light weight construction, suppression of the carrying axles, increased stability in running, simple designs that are easy to maintain.

STEAM TRACTION.

Faced with these two redoubtable adversaries, steam traction takes its stand on its economic and technical efficiency.

Maintenance costs are reduced thanks to the spacing of operations, and thanks also to the reduction in the time out of service.

Progress has also been made in the thermal and thermodynamic fields (high pressures, superheating).

GAS TURBINE.

Apparently very complicated, the gas turbine has held the attention of technicians owing to its remarkable output and low running costs.

Gas turbine locomotives are in service in Great Britain and France.

Studies are being made as regards the use of coal and other fuels than heavy oil and coal.

* * *

To Mr. BROUCKAERT, « Directeur du Matériel et des Achats » of the S. N. C. B., Member of the Permanent Commission of the International Railway Congress Association, representing the Operators, was confided the task of summing up these days.

The railway finds itself in the presence of young techniques, which are improving every day.

The cost of traction depends upon two essential factors : the cost of labour and the cost of power.

It is as a function of these facotrs, which vary from one country to another, the relative importance of which depends also upon the amount of traffic, that one or other of the new techniques will be found to have the advantage.

For shunting services, Diesel traction has the greatest advantages.

* * *

Those who took part in these international meetings were invited to a demonstration run from Liège to Ostend, which gave the S. N. C. B. a chance of showing what their Diesel locomotives BB 201 and CC 202 could do, as well as their most recent electric locomotive, the BB 122.

F. B.

[656 .222 (44)]

Revision of the operating conditions on the lines of average importance of the South-Eastern Region in order to speed up the fast trains,

by Stéphane Mermier,

Directeur de la Région du Sud-Est de la Société Nationale des Chemins de fer français.

(*Revue Générale des Chemins de fer*, February 1955.)

Between the lines with very important traffic, improving the operating conditions of which receives constant attention, and the secondary lines where economy is of the greatest importance and in every case comes before speed even when a passenger service is still in operation, there are a certain number of average lines which carry a considerable amount of passenger traffic by express trains.

The requirements of these clients, who have now become accustomed to the shorter journey times that the motor car has made possible, even with the cheapest makes of car, have made it necessary for the railway to improve the journey times on these average lines if it is to remain in the competitive field.

This obligation is of particular importance on the South-Eastern Region, owing to the remarkable performances obtained or which will be obtained owing to the electrification of the main Paris-Lyons artery and some of the adjacent lines; passengers cannot understand why after travelling at these record speeds, at the end of their journey they have to put up with very modest average speeds.

It therefore appeared of interest to revise systematically the operating conditions on the average lines of the South-Eastern Region in order to improve the average running speeds of the fast trains.

This revision was entrusted to a special Commission on which the three main departments of the Region were represented under the chairmanship of the manager: it should never be overlooked in fact that the railway is a whole and that railway problems cannot be divided up artificially between the three great traditional departments. The work of this Commission, which was set up at the end of 1951, has now been completed, since the possible improvements have either been made or the programme has at least been laid down.

The map given in figure 1 shows the geographical extent of this revision. It will be seen that it covered:

— the whole of the single track lines of the Savoy (Aix-les-Bains to Annemasse, La Roche-sur-Foron to Saint-Gervais-les-Bains, Bellegarde to Evian, Saint-Pierre-d'Albigny to Bourg-Saint-Maurice), lines which we think are unique in France owing to the great amount of passenger traffic they carry, their many curves, their difficult profile, and the difficulties imposed by single track working (1);

— a certain number of lines radiating from Lyons, serving important regional

(1) On the Aix-les-Bains-Saint-Gervais-les-Bains-le-Fayet run for example, throughout the year there are an average of 13.6 fast or express trains a day in both directions, with particularly heavy peaks, especially at Christmas and the New Year: on the 23rd December 1954 14 passenger trains arrived at Saint-Gervais - les - Bains - le - Fayet betwen 6 and 11 a.m.; on the 2nd January 1955, 16 trains left between 8 p.m. and 1 a.m.

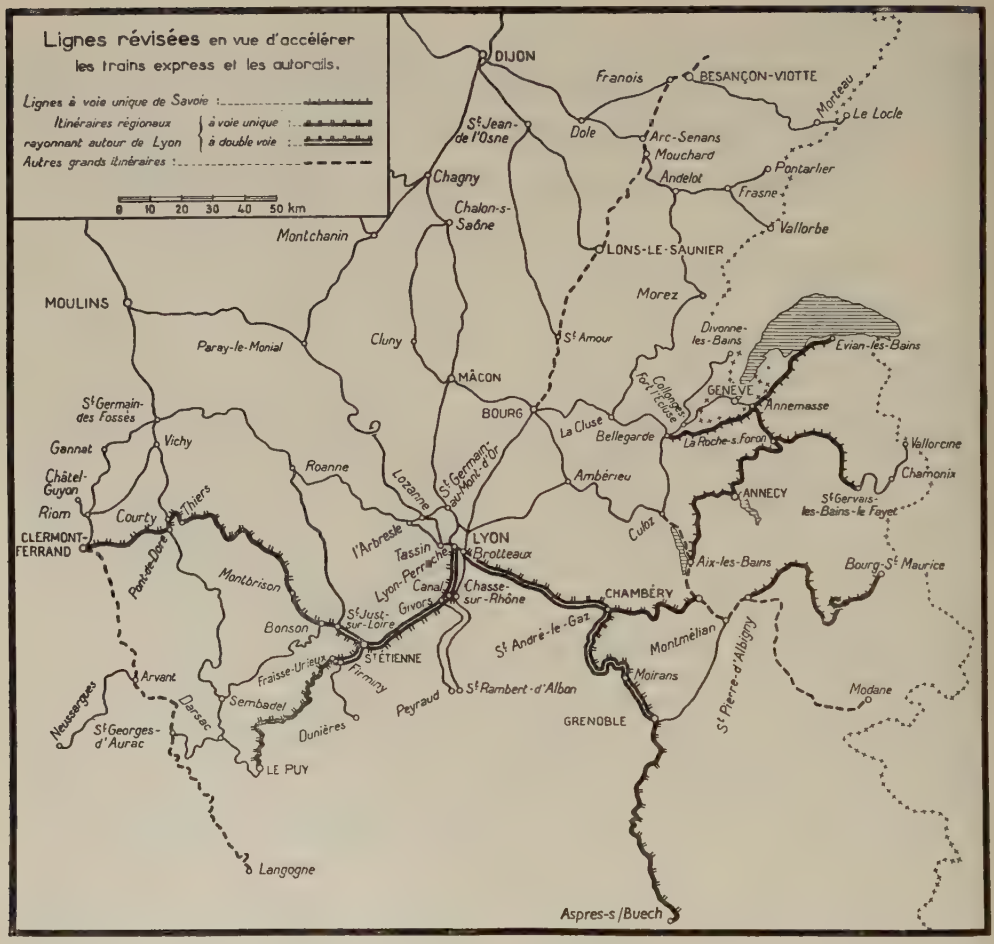


Fig. 1. — Lines revised in order to speed up the express trains and railcars.

Single lines in Savoy . . . .

Regional lines . . . *radiating around Lyons* . . . } *single track; double track.*

Other important routes . . .

centres: Lyons-Grenoble, Lyons-Saint-Etienne, Saint-Etienne-Clermont-Ferrand, Saint-Etienne-Le Puy, Saint-André-le-Gaz-Chambéry, all with considerable traffic, particularly liable to competition, and at least in the case of the first two, liable to be compared with the performance of the services between Paris and Lyons;

— finally, on lines assuring important international and interregional services, such as Culoz-Modane, Besançon-Bourg and Clermont-Ferrand-Langogne, the services on which, from the point of view with which we are now concerned, had not been revised for a great many years.

Excluded from this revision were routes

undergoing electrification, which were dealt with when the corresponding programmes (1) were prepared, such as the Bourbonnais line, where any great improvement of operating conditions cannot be expected until better traction methods are available (high speed steam locomotives with four driving axles or Diesel engines) which are not yet available, or a considerable amount of work has been completed, such as the elimination of its many bottlenecks.

The revision we carried out — we must insist upon this — was primarily concerned to avoid any considerable additional cost. All the work taken in hand was carried out under a suitable orientation of the funds available from the normal operating budget of the Region (maintenance and heavy repairs; small additional works i.e. « Article 50 ») or, exceptionally, as supplementary work which had already been approved and therefore already justified.

None of the standards governing maintenance were modified, or even stretched a little way to achieve the desired object. We are convinced that we have achieved a revision which has been in no way costly and in fact in many cases has even been a source of economies owing to the withdrawing of speed restrictions, the reduction of journey times and doing away with double heading.

The factors upon which we worked to achieve our object come under four headings :

— speed on the open line;

— difficult points, and the signalling;

— methods of traction;

— the timetables.

For each of these we will give in turn the methods followed. To end with, we will illustrate the results obtained by a few actual examples.

SPEED ON THE OPEN LINE.

The first condition for obtaining improved timings on average lines with fast trains was obviously to have as high speeds as possible on the open line.

However, in view of the nature of these lines, there could be no question of improving their characteristics by undertaking any important works, nor of burdening the future with increased maintenance costs. Increases in the speed has therefore to be obtained, as we have already said, without any appreciable modification of the present position, making the greatest possible use of existing factors and by very careful allocation of the sums normally set aside for maintenance and heavy repairs on these lines.

The speed on the open line depends essentially upon the following three factors :

— the layout of the line;

— the superstructure and its condition;

— structures (bridges, viaducts and tunnels);

— the level crossings.

We had therefore to deal with each of these factors.

a) *The layout of the line.*

The maximum speeds authorised on these lines in terms of the layout were based, at the beginning of the period during which the present work of revision was carried out, upon the old rules laid down before the setting up of the S. N. C. F. The systematic reduction in speed put into force as soon as the war began, the long period of shortages of materials which followed it and made it necessary to devote the labour available for maintenance to prolonging the life of the materials in use, had not been

(1) Apart from the electrification of the single track lines in the Savoy, which were originally treated as « trial lines » with the minimum of work.

conducive to any review of the maximum speeds.

It is quite certain, however, that the old regulations laid down at an epoch when the knowledge of the reactions between vehicles and the track were rather empirical, made too much of the respective defects and allowed too great a margin of safety, to make sure that comfort was not too bad and safety absolutely certain. This was so in particular on curves of small radius which are a characteristic of these lines, usually very sinuous.

The regulations now imposed by the S. N. C. F. to determine the maximum speeds are based upon a much better knowledge of the conditions under which vehicles run through curves, especially the entry to the curve. Making full use of the flexibility given by a simultaneous study of the layout and the superelevation by the versine method, it has been possible to replace the sudden curves of the old layout by curves with a progressive transition which in spite of the considerable lack of superelevation assure that the passengers seated in vehicles in a good state of repair will be sufficiently comfortable.

In addition a considerable increase in speed has been obtained by giving up the old custom of fixing as the maximum speed between two stations, the speed compatible with the minimum radius of curve on that section. There is no drawback to this method on lines with an easy profile where the builder has been able to make all the curves of equal radii. But on lines in hilly country, it has often be necessary to make use of much smaller radii at certain points to overcome certain difficulties without embarking on important works. To impose the speed suitable for these special curves upon the whole of the run between the stations penalises the whole line.

The standard regulations of the S.N.C.F. which authorise, thanks to the use of pegs Z and R (1) accurate measuring of these zones in which the speed must be restricted, has made it possible to reduce the length of the restricted portion and the corresponding reduction in speed to that which is strictly necessary.

The final difficulty concerning the question of the layout and superelevation of the track was due to the fact that on certain sections on a gradient, the low speed of the freight trains had led, in order to avoid abnormal wear of the inner line of rails, to the superelevation being fixed at a lower value than that needed to make full use of the layout in the case of the fast trains. Modification of the organisation of freight transport, carefully studied here again with the object of avoiding all extra cost, was found practicable in certain cases, in order to increase the speed of the slow goods trains, give the superelevation its usual value and, the final objective, increase the authorised speed.

b) *The superstructure.*

A study of the layout having shown that high speeds could be allowed after correction of the versines or by introducing limited speed restriction, it might be feared that the superstructure would not stand up to these new speeds without important renewal or reinforcing work to eliminate worn or weak parts.

In practice, we found there were two distinct situations, in view of the need already explained not to undertake any financial commitments with the sole object of increasing the speeds of the passenger services.

On some of the lines under revision, there is a relatively great or growing freight traffic which, quite apart from

(1) Pegs Z and R consist of posts set up on the start « Z » and the finish « R » of the section of line that must be run over at reduced speed, the section thus localised being preceeded at some distance by a sign showing the speed which is lit up at night.

any other consideration has made it necessary to carry out renewal and reinforcement work to enable the track to stand up to the heavy locomotives and wagons with heavy axle loads — « super-loaded » wagons (1) — which are becoming increasingly required on lines serving districts with heavy industries, mines or hydro-electric stations. The improvements made to the track for these reasons have made it possible to agree to increases in the speed allowed on these lines for all classes of passenger services, from which railcars obviously profit by the increased user. As an example we may mention Saint-Pierre-d'Albigny to Alberville and Bourg-Saint-Maurice on which important sections have been renewed — with second hand rails — owing to freight traffic requirements.

On other lines, on the contrary, there is relatively little freight traffic and the fast passenger services are usually worked not by trains but solely by railcars. Although from the point of view of comfort, such vehicles require a good quality layout and level of the line, their low weight per axle does not lead to any undue wear of the track. They can therefore profit by the removal of speed restrictions without incurring any expenditure for reinforcement or renewal. The speed restrictions have therefore only been removed in the case of railcars and for certain light locomotives which do not harm the track, whilst they have been retained in the case of the heavier steam locomotives. This is the case, for example on the Saint-Etienne au Puy and Saint-Etienne to Clermont-Ferrand lines.

c) *Structures.*

Certain structures on the lines in question could only be run over at reduced speed. These restrictions sometimes covered all locomotives, sometimes only certain classes. On the other hand, there were no speed restrictions in the case of railcars.

The same problem therefore arises in the case of these structures as in the case of the superstructure.

The inconvenience caused by restricting the speed to a relatively low value is so great even with the old running speeds, that a programme to strengthen these structures is in hand on various lines in the Region with sufficiently important traffic, to allow of the better utilisation of heavy locomotives and a reduction of the additional fuel consumption involved by these special spots. It was therefore sufficient to so adjust the carrying out of this programme, which is to be spread over several years, as to give priority to the lines on which a general increase in the speed could be given by applying the above mentioned conclusions.

On lines run over by railcars, increases in the speeds have been granted without difficulty, without any additional strain on the bridges, though the restrictions remain in force in the case of the steam locomotives.

d) *Level crossings.*

On the lines under revision, there are a certain number of level crossings without keepers, with or without automatic signals, according to recent ministerial decrees or early regulations.

In all these decrees, an essential factor is the minimum visibility at certain well defined points from the road across the level crossings.

It has therefore been necessary to review

(1) On the lines of the S. N. C. F. as a whole the load per axle must not exceed 17 metric tons and the weight per metre run must not exceed 5.4 metric tons. However, *on certain lines*, certain heavily loaded wagons, known as « super-loaded » wagons are allowed to run without their load being considered as exceptional, the weight per axle exceeding 17 metric tons but under 20 metric tons, so that their total weight per metre run can exceed 5.4 metric tons but not exceed 8 metric tons.

the situation systematically when the speed is increased.

Wherever so doing did not reduce the visibility below the prescribed limits laid down in the decree, there was no problem about restoring the crossing keeper.

On the other hand, in other cases, other solutions had to be found so that it would not be necessary to have a keeper again, in view of the saving obtained by doing without one.

Various solutions have been used, the simplest being the presentation of a new « dossier » for all those level crossings which though they no longer meet the conditions of the original ministerial decree, do meet the more flexible conditions of more recent decrees.

Where this purely administrative solution was impossible, an endeavour has been made to improve the visibility to the minimum required for the new speeds, either by removing obstacles or by slightly displacing the telecommunication lines which often impede visibility by acting as a screen.

Finally, in a few cases, where the above mentioned solutions were impossible, it was necessary to retain the old speeds within the zone of visibility, or if this was too inconvenient, put back the gates by having them distant controlled, which did away with the need for a keeper. This latter case is however very exceptional.

In fact, and this was the important point, the use of all these solutions has made it possible to make the necessary improvements without having to restore a keeper in any case.

Apart from its effects on level crossings without keepers, the increase in the speed involved an alteration to the warning distances at level crossings with keepers, equipped with automatic warning. As the times were calculated with a wide margin, very few installations had to be modified, and in most cases it was only necessary to move the warning pedal slightly.

Finally, a few level crossings working on the « closed » system had to be equipped with warning installations, as the visibility was reduced to less than 20 seconds.

SPECIAL POINTS AND THE SIGNALLING.

a) *Single track stations.*

Single lines on the old P. L. M. system were for the most part equipped with stations on the up road which could be run through at 30 km (18 miles)/h, and when the layout of the equipment was suitable up to 40 km (25 miles)/h. This type of station was very simple to build and easy to operate; but there is no point in going into the inconvenience caused to the operating as regards the average train speeds, by such speed restrictions, especially in the case of single lines with heavy traffic where there have to be many crossing points. Such points become more and more of a nuisance as the speed on the open line becomes greater.

Certain stations on the single lines in the Savoy were however specially equipped, even in the days of the P. L. M. being of the type now known as « up road stations, Savoy type ». These stations the points at the entry of which are locked while those at the exit can be taken trailing, can be run through without stopping at 60 km (37 miles)/h; this restriction is due on the one hand to the existence of points which can be run through at the end of the double section and on the other hand to certain conditions in the interlocking, a description of which would be outside the scope of this article. This speed of 60 km/h, which was quite satisfactory 25 years ago, in view of the running speeds and methods of traction used at that time, is no longer acceptable now that the lines in question include many sections where the speed on the open line has been increased to 100 km (62 miles)/h, and where the methods of traction used, especially on the electrified sections or those

about to be electrified, make it easy to reach such speeds.

What have we done to improve the single track stations ?

The first solution was to alter these stations so that they could be run through at speed, by doing away with the double line and locking the points of the service track. This is certainly an economical solution, but as it means giving up a crossing point, it can only be used when the theoretical timing and actual operating conditions allow (1) : i.e. it is often objected to by the traffic department. However, during our work of revision, we found a small number of cases on lines with relatively little traffic where this solution was recognised as acceptable, and was found in practice to give rise to no difficulties.

On the less important single lines (for example the Saint-André-le-Gaz to Chambéry line), we were able at the cost of a small amount of work incorporated into the maintenance work, to turn the up road stations of the South-East type where a speed restriction of 30 km/h was still in force into 40 km/h stations.

As for the « Savoy type » up road stations, it was agreed that if it was impossible to increase the speed of 60 km/h when taking the points at the exit, it was possible without risking the safety to increase the speed to 70 km/h when running through the entry points and when running through the station. Such stations could therefore be passed at 60 to 70 km/h.

But the only really satisfactory solution to the problem of single line stations is the through road. This unfortunately is rather expensive in view of the work involved to the track and signals, especially when it is necessary, in view of the frequence with which crossings take place, to fit distant control of the points; the cost per station is on the average 5 to 6 M. (*) for the work to the track and signals.

A programme approved by the Higher Management in 1942 provided for the installation of a through road on certain important sections of single track on the old P. L. M. system. This programme was begun, but the difficulties caused by the war and the after war period made it impossible to complete it. By means of the annual credits for supplementary work allocated to the Region, we were able to begin again on this programme, which is now nearly completed, and we have put forward an additional programme which is now being approved.

The operations covered will definitely pay for themselves when the number of trains running through non-stop is fairly high : for example on the electrified line from Aix-les-Bains to La Roche-sur-Foron, where owing to electrification, the saving in current can be more accurately gauged, the saving due to turning « Savoy type » up road stations into through stations is 19.3 % (cost 66 M.; annual saving of 12.5 M. on power consumption and wear of brake shoes).

When the present programme has been completed, the most important of our single lines in Savoy (Aix-les-Bains-Annemasse; La Roche-sur-Foron-Saint-Gervais-les-Bains; Bellegarde-Evian; Saint-Pierre-d'Albigny-Bourg-Saint-Maurice) will be equipped with through stations, with very few exceptions : stations at which all trains stop — which remain 40 km/h up road stations — and stations on certain sections where the speed on the open line does not exceed 85 km (52 miles)/h and where the number of through trains is small, which will remain « Savoy type », at 70-60 km/h.

(1) In this connection, it should be noted that speeding up the services, by reducing the time between consecutive stations, favours the suppression of a few crossing points.

(*) 1 M. = 1 000 000 fr. fr.

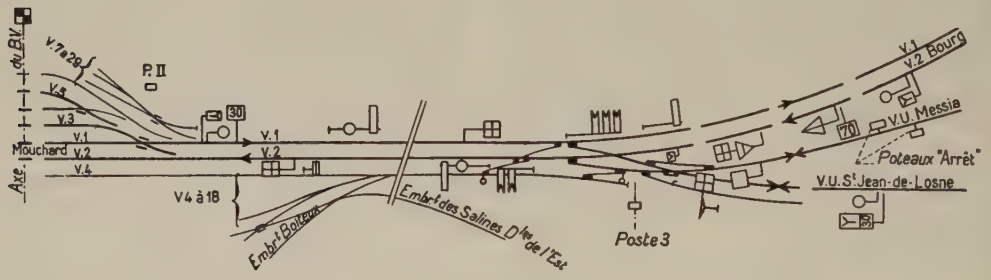
b) *Other difficult points.*

The lines under revision, designed on the usual P. L. M. basis, include a great many difficult points where the layout of the track equipment makes it impossible to exceed 30 km (18 miles)/h; with this speed restriction often goes the requirement to come to a stop, a solution adopted at the time to simplify the signalling.

The work of revision undertaken has not been very fruitful in this field, as it was found that it would be very expensive to do away with the stop or increase the speed. Apart from lines to be electrified — electrification necessarily implies an alteration to the line with interesting possibilities — only in very rare cases has it been possible to do away with the stop, remove such points, or merely increase the speed, without appreciable expenditure.

As an example it may be mentioned that on the Besançon to Lyons lines, a speed restriction of 30 km/h on track 1 at the P. 3 junction of Lons-le-Saunier, 1 300 m (1 421 yards) from the « B. V. » of this station in the direction of Bourg, has been removed by (see fig. 2) :

Previously.



Now.

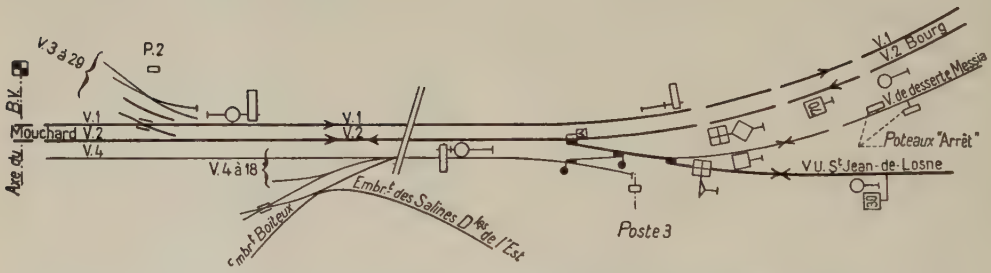


Fig. 2. — Putting Post 3 on the Lons-le-Saunier line out of service and suppressing the dificult point, with a 30 km (18 miles)/h speed restriction, at the branch points on track 1.

— putting line 2 between the branch and the station into general use, allowing trains to run in either direction on the Saint-Jean-de-Losne line;

— suppressing the points at the P. 3 branch.

This work, which did not cost more than 1.7 M. made a pointsman redundant, as post 3 only had to be manned when trains from the Saint-Jean-de-Losne line ran through.

Naturally, this aspect of the question has not been lost of sight as far as the future is concerned and all maintenance

operations will be taken advantage of, especially when the regional points reach their limit of wear and have to be replaced by modern equipment, when the speed restrictions will be raised.

c) *Signals on the open line.*

When the braking regulations were standardised by the S. N. C. F. in 1946, the standard regulations then adopted, intended above all to limit different ways of siting the signals, classified the lines into lines called « important » and lines called « secondary » the latter with down gradients less than or equal to 25 mm per metre having speeds 10 km (6.2 miles) below those of the former. Owing to this, certain sections of line under revision have speed restrictions lower than that required by the layout and superstructure of the track. We checked if it was possible to alter the classification of these lines so as to raise the speed on the down gradients; certain cases were found in which it was possible to do so, if some signals were moved a little.

METHODS OF TRACTION.

The open line having been arranged to allow of as great a speed as possible, and special points having been revised as far as was reasonable, it was necessary that the methods of traction used should make it possible to reach speeds as close as possible to those authorised.

a) *Electrification.*

As it was laid down in principle at the beginning that important work could not be undertaken, obviously the electrification of such and such a line could not be undertaken. However, in certain cases, we were able to profit by the electrification resources of electric traction :

— on the Aix-les-Bains to La Roche-sur-Foron line, already electrified as a «trial line » in single phase 25 000 V 50 Hz;

— the La Roche-sur-Foron-Annemasse section and the La Roche-sur-Foron to Saint-Gervais-les-Bains-le-Fayet line, being electrified on the same system.

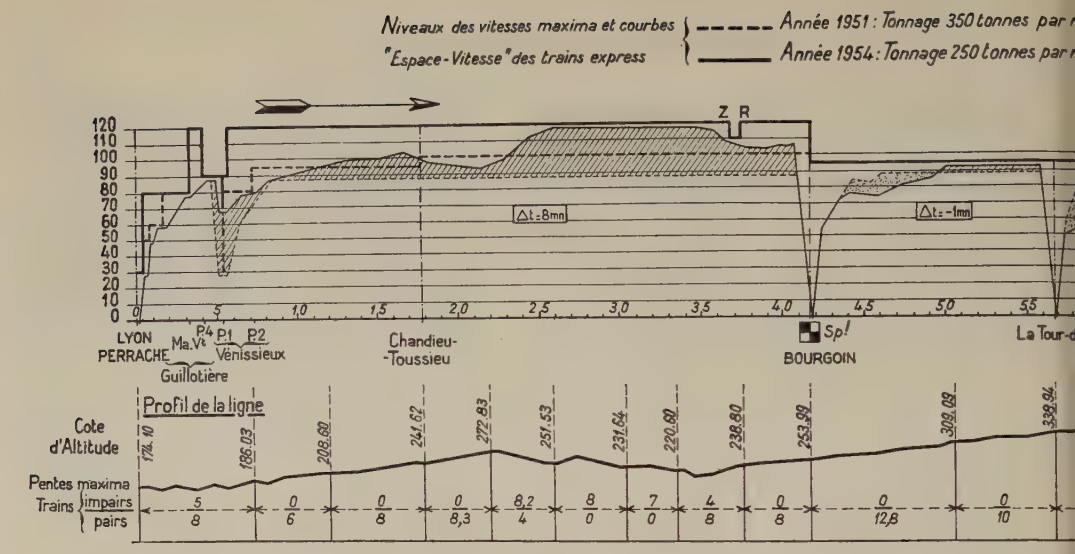
In these three cases, the work of revision naturally took into account the possibilities, known or expected, of electric locomotives. In particular, mention may be made of the possibilities of these locomotives which make it possible to run, except in the case of heavy trains being hauled up the heaviest gradients in the section, at speeds close to those authorised for the open line (between 85 and 100 km [53 and 62 miles]/h), a weighty argument in favour of turning the Savoy type up road stations on the sections in question into through stations.

b) *Steam locomotives.*

The relatively easy position as regards the stock of steam locomotives on the S. N. C. F. owing to the freeing of many up-to-date steam locomotives due to the electrification of the main routes, left us a great freedom of choice in determining the type of locomotive to be used on each line. In addition, amongst the lines studied, nearly all those on which the hauling of express trains by steam locomotives is still of commercial interest, in spite of the development of the railcar, allow 20 t axle weights.

We therefore had a choice of three locomotives : two types of « Mikado » the 141 E (or F) of P. L. M. origin and the 141 R of the well known type imported from the United States after the Liberation and a « Pacific » type, the 231 G of the P. L. M.

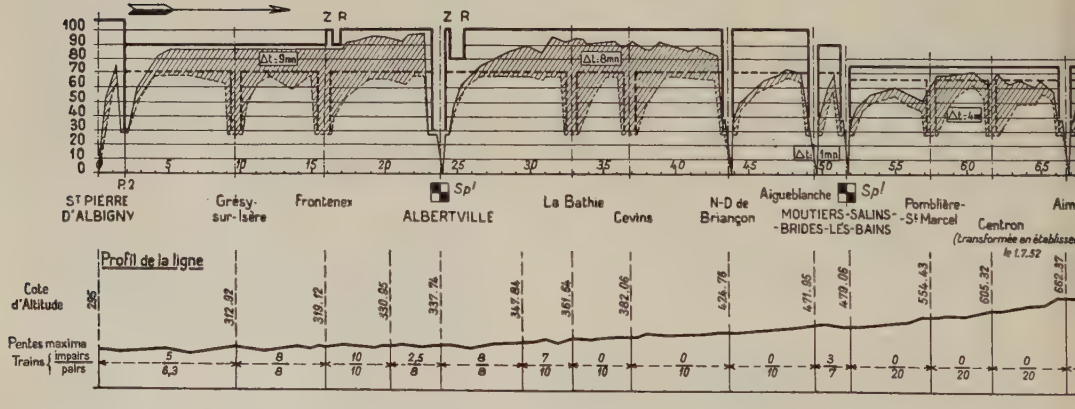
In the case of the 141 ex P. L. M., our work of revision coincided with the completion of studies to increase the speed of these locomotives : designed to run at 105 km (65 miles) /h, these locomotives had to be limited to 90 km (56 miles) /h because of certain defects in their behaviour on the track; to remedy this, it was decided to modify the horizontal equalising bar between the



Maximum speed levels and « Space/Speed » curves for express trains

— — — *1951 : Tonnage : 350 t by steam*
——— *1954 : Tonnage : 250 t by steam*

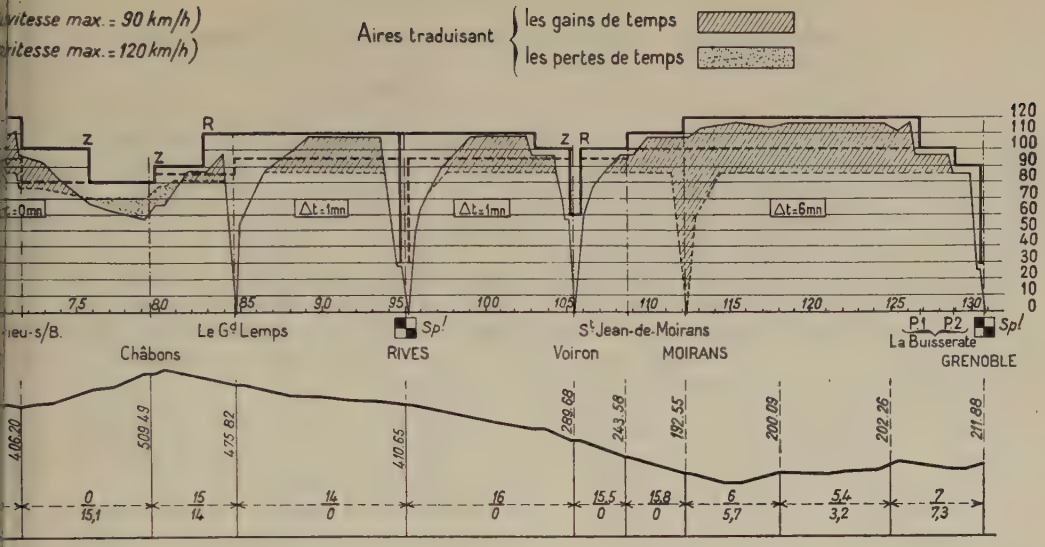
Fig. 3. — Ly



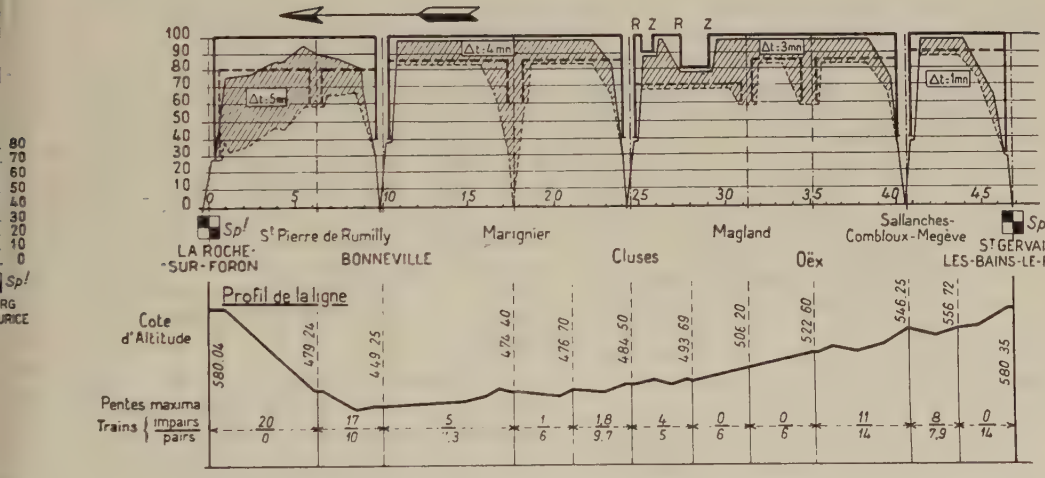
Maximum speed levels and « Space/Speed » curves for a 350 t express train

— — — *1951 : Hauled by locomotive 242 TC (*
Double heading on the Albertville-Bou
——— *1954 : Locomotive 141 F hauls the tra*
(Max. speed : 105 km/h).

Fig. 4. — Saint-Pierre-d'Albigny to Bourg-Saint-Maurice (down line).



speed : 90 km/h).
speed : 120 km/h).
Areas showing { *a saving in time* / *a loss in time*
ne (down line).



Maximum speeds and « Space/Speed » curves for express trains

— — — *1951 :*
Tonnage : 400 t by steam locomotive 141 D (Max. speed : 90 km/h).
——— *1956 :*
Tonnage : 500 t by single phase electric locomotive CC. 20.001 (Max. speed : 100 km/h).
After the introduction of electric traction at the end of 1955.

Fig. 5. — La Roche-sur-Foron to Saint-Gervais-les-Bains-Le Fayet line (up line).

first and second pair of wheels and to improve the centralising gear of the first pair of wheels, which has made it possible for these locomotives, now known as 141 F, to run at 105 km/h.

With this stock at our disposal, with no other restriction than certain ones on the 141 R, which are heavier, we are free to select in each case the particular type of locomotive most suitable for hauling the trains we wish to speed up, taking into account the profile of the line, the speeds on the open line, the number of stops required and the weight of the trains to be hauled, a function of their average user.

Many typical runs were plotted, and certain trial runs were made, to see what would be the best solution in each particular case.

In most cases, particularly where the speed on the open line did not exceed 100 km (62 miles)/h, locomotives with four driving axles gave the best results, and amongst the latter, the 141 R were better than the 141 F wherever 20 t axle loads were permissible.

On the other hand, on lines where the authorised speed exceeded 100 km/h, there were a certain number of cases in which the 231 G locomotives, authorised to run at 120 km (74 miles)/h gave the best performance, provided the weight of the train to be hauled did not exceed 200 or 250 metric tons, which usually was sufficient to meet the requirements of regional services.

Fox example on the Lyons to Grenoble line, where our competitive position is particularly difficult owing to the hilly and tortuous character of the line, the distance by rail being appreciably longer than the distance by road, we have been led to replace the 141 R by the 231 G to haul the light express trains. Figures 3 to 5 compare the space/speed curves obtained with these two types of traction: the 231 G which can only haul 250 t whereas the 141 R can haul 350, climbs more slowly but runs better on the level and good sections, thereby gaining an appreciable amount of time.

c) *Railcars.*

Although our stock of railcars is not as good as our stock of steam locomotives, similar studies have been made as regards the choice to be made between the different possible types:

— standard railcars with mechanical drive of 600 and 300 HP able to haul a trailer;

— Decauville railcars, with electric drive, 600 HP also able to haul a trailer;

— Berliet 300 HP railcars, with electric drive, which cannot take a trailer.

Here again the typical runs were plotted and certain trial runs made under various hypotheses corresponding to actual operating conditions.

In the particular case of the Lyons to Grenoble line, which we will again take as our example, a line where the maximum speed on the open line applicable to railcars before the revision was carried out was never more than 110 km (68 miles)/h and that only over short sections, the services were generally worked by railcars of the Renault type (VH or VHD) which cannot exceed 100 km/h.

The standard 600 HP railcars, which are more comfortable and capable of running at 120 km (74 miles)/h authorised on a good proportion of the line since it was overhauled, have gradually replaced the Renault railcars and made it possible to introduce better timetables and better services.

A few runs are however made with the Decauville railcars with electric drive, top speed 110 km/h, but very quick to pick up speed, an invaluable quality in the case of stopping and semi-through services on hilly lines.

TABLE Fig. 3.

Stations served	Theoretical journey time 1951	Theoretical journey time 1954	Time saved	Time lost
Lyon-Perrache .				
Bourgoin . . .	38 mn	30 mn	8 mn	—
La Tour du Pin	12 mn	13 mn	—	1 mn
St André-le-Gaz	9 mn	10 mn	—	1 mn
Le Grand-Lemps	19 mn	19 mn	—	—
Rives	10 mn	9 mn	1 mn	—
Voiron	10 mn	9 mn	1 mn	—
Moirans. . . .	7 mn	17 mn	6 mn	—
Grenoble . . .	16 mn			
Totals . .	2h01'	1h47'	16 mn	-2mn
Time saved.			14 mn	

TABLE Fig. 4.

Stations served	Theoretical journey time 1951	Theoretical journey time 1954	Time saved on the run
StPierre d'Albigny			
Albertville . .	30 mn	21 mn	9 mn
N.D. de Briançon	25 mn	17 mn	8 mn
Aigueblanche .	8 mn	8 mn	—
Moutiers-Salins-Brides-les-Bains	5 mn	4 mn	1 mn
Aime	23 mn	19 mn	4 mn
Landry	11 mn	10 mn	1 mn
Bourg St. Maurice	10 mn	9 mn	1 mn
Totals . .	1h52mn	1h28mn	24 mn

TABLE Fig. 5.

Stations served	Theoritical journey time 1951	Theoritical journey time 1956	Time saved on the run
Saint-Gervais-les Bains			
Sallanches-Combloux-Megève .	7 mn	6 mn	1 mn
Cluses	16 mn	13 mn	3 mn
Marignier . . .	10 mn	12 mn	4 mn
Bonneville . . .	6 mn		
La Roche-sur-Foron . . .	15 mn	10 mn	5 mn
Totals . .	54 mn	41 mn	13 mn

THE DRAWING UP OF THE TIMETABLES.

The possibilities of the lines having been defined, as well as the most suitable engines for working them, there remains to make full use of them, the drawing up of the timetables. This is the daily life of the traffic department. During the work of the Commission, however, we endeavoured to take three considerations into account:

— reducing the train loads, including the railcar services, to the minimum compatible with the traffic;

— suppression of certain stops, which were perhaps justified in the past but are no longer necessary owing to the evolution in the traffic;

— a very close study of the time taken for stops and the connections.

Amongst the results obtained in this order of ideas, mention may be made of the following:

— modification of the character of certain express trains from Paris to Savoy, on the terminal sections Aix-les-Bains to Saint-Gervais-les-Bains-le-Fayet, the better to suit their character of long distance trains, and also to take into account the new possibilities of the supplementary services by motor coaches on the recently electrified sections. The number of intermediate stops on the route in question made by the regular night trains Nos. 613 and 614 has been reduced from 12 to 6 thereby;

— running railcars from Lyons to Grenoble without intermediate stops as from May 1955.

These modifications may have led to certain local protests at times; in our opinion, they are in line with the future evolution of the railway.

	Type of service	Average journey time Summer of			Time saved between 1951 and 1955
		1939	1951	1955 (proposed)	
Aix-les-Bains to St-Gervais-les-Bains	Train	2 h 55	2 h 43	2 h 17	0 h 26
le-Fayet (125 km)	Railcar	(1)	2 h 21	2 h 05	0 h 16
Chambéry to Bourg-St-Maurice	Train	2 h 20	2 h 39	2 h 02	0 h 37
(106 km)	Railcar	(1)	2 h 18	2 h 01	0 h 17
Lyons to Grenoble (129 km)	Train	2 h 00	2 h 12	1 h 49	0 h 23
	Railcar	1 h 48	1 h 46	1 h 27	0 h 19
Grenoble to Lyons (129 km)	Train	2 h 00	2 h 12	1 h 50	0 h 22
	Railcar	1 h 55	1 h 55	1 h 26	0 h 29
Lyons to St-Etienne-Châteaucreux	Train	1 h 05	1 h 10	0 h 55	0 h 15
(58 km)	Railcar	0 h 59	0 h 50	0 h 45	0 h 05
St-Etienne-Châteaucreux to Lyons	Train	1 h 03	1 h 04	0 h 54	0 h 10
(58 km)	Railcar	(1)	0 h 47	0 h 42	0 h 05
Culoz to Modane (135 km)	Train	2 h 03	2 h 10	1 h 55	0 h 15

(1) No railcar services over this route in 1939.

SYNTHESIS OF THE RESULTS OBTAINED.

Figures 3 to 5 show certain characteristic factors for some of the lines covered by this revision, as they were previously and since the revision, in particular the space/speed curves, as well as a comparative table of the lengths of runs between stopping points. It will be seen that substantial results have been obtained.

As for the commercial lengths of the runs, including the stops, the table on the preceding page gives a comparison, for some of the runs in question, of the gross times for the best services of each type, train or railcar, included in the summer 1951 timetables, the commencement of our work of revision, and the proposed timetables for the summer of 1955. We have also included for your information the best runs corresponding to the summer services in 1939.

Certainly the average speeds achieved are still low, and it would be a presumption on our part to affirm that a comparison of the journey times is always in favour of the railway, compared with that of an average sized motor vehicle, even one driven conservatively: it cannot be otherwise when the difficulties of the railway lines in question are considered, and the character of the services run over them; but the savings in time are still appreciable, and it must not be forgotten, once more, in judging these results, that the improvements made in the speed of transport have been obtained without any appreciable increase in expenditure.

[625 .28 (43)]

The problems of the changing of traction structure,

by Dipl.-Ing. Friedrich Flemming, Francfort (Main).

(*Eisenbahntechnishe Rundschau*, November 1954.)

The cost of the traction department can be reduced, on the one hand, by purely organisationary measures, and on the other, by technical rationalisation methods. The first named cost little or nothing, whilst the latter are expensive.

It was therefore only logical to study rational methods of organisation first of all. Amongst these can be included, for example :

a) rationalisation of the stock of steam locomotives, i. e. a reduction in the number of different series of locomotives from well over 100 to the present 50, as well as a reduction in the number of types allocated to each of the sheds. In the case of the other motor vehicles, it has not been possible to cut down the number of types to any great extent, as the total stock is insufficient for operating requirements;

b) increasing the specific output of motor vehicles. In July 1954, figures never reached before were achieved, viz. 232 loc.-km per working day for the steam locomotives and 349 loc.-km for the electric locomotives;

c) reorganisation of the time spent in dealing with motor vehicles before and after their days service, which results in a reduction of the number of traction personnel required;

d) doing away with and down grading traction regions and sheds.

But the possibilities of rationalisation offered by purely organisationary measures are already practically exhausted, and it is necessary to apply technical rationalisation methods more widely. Amongst these must be included the complete making good of war damage to local installations for small and general engine overhauls, in order to restore normal working conditions. Amongst these must also be included the transformation of the traction structure owing to the replacing of steam locomotives by up-to-date electric or internal combustion engines. This complete change of structure requires at the same time a very urgent technical rejuvenation of the very ancient portion of the stock of steam locomotives.

A great deal has already been written about this change in structure. It has nearly all been from the pens of those interested in the construction of engines. Here we wish to call attention to certain problems in the same field from the point of view of the traction department, in other words the users.

* * *

Under present conditions in Germany, *electric traction* supplied from the catenary (or on urban lines, from the third rail) is the most elegant, cleanest, most powerful, and after a certain amount of traffic, the most generally economical method of traction. Electric traction can give with very small motor units powers that no other method of traction can realise economically; for example the new series of E. 10 locomotives, weighing about 80.3 t. in working order, and about 15.9 m (52′) in length over buffers develop up to 3 800 kW at an hourly rating and have a maximum speed of 150 km (93 miles)/h. In particular, they can achieve high speeds on steep up gradients and have great

acceleration on starting. The traction saves at least 50 % of the amount of coal needed to assure the same service by steam locomotive. In many cases, the engine can be driven by one man. The total saving with electric traction compared with steam traction is of the order of 30 to 40 %. In addition, electric traction has the advantage that its sources of power, coal and water power, are available in sufficient quantities in the country itself, which assures the necessary security in supplying power, as well as a certain stability in its price.

To know if it will pay to electrify a line, there are certain criteria which have been evolved as the result of studies on profitability, for example the annual consumption of power in kWh per kilometre of line, or the number of gross tons transported per kilometre of line. In addition, individual studies are made of the profitability of lines it is intended to electrify. These studies show that on the Deutsche Bundesbahn it would pay to electrify all the main lines with heavy traffic as well as some of the branches off these lines, provided that the traction on these small lines with little traffic can be assured by engines which will also be needed on the main line. This is because about half the capital cost of electrification is spent on the motor vehicles. Our lengthy experience has shown that the data on which these investigations into profitability are based are so indisputable that it is not even necessary to make any estimates for some of them.

This has resulted in the preparation of an *electrification programme* which in round figures covers 4 800 km (2 982 miles), which has already been begun (Nuremberg-Würzbourg, Bruchsal-Heildelberg/Mannheim, Bâle - Carlsruhe, Düsseldorf-Hamm). When this programme has been completed, 6 600 km (4 100 miles) of line, i. e. 21.5 % of the whole system of the Deutsche Bundesbahn will be electrified, compared with about 1 800 km (1 118 miles) or 6 % at the present time. To avoid the cost of overhead lines in marshalling yards, Diesel locomotives will be used as far as possible in these, even on the electrified lines.

On certain short services, *battery railcars* will be used to a greater extent than up to the present. This type of vehicle has certain great economic advantages over the others, especially when current is available at a reduced rate during the night. However, its limited radius of action and the fact that it must remain within a certain distance of the charging station limits its extension. In its new form of a bogy railcar, it has the advantage not only of being clean, but also of running relatively silently and steadily. Investigations have been started concerning the introduction of electric battery railcars on certain services; in particular mention must be made of a large scale programme for the use of such vehicles on the Schleswig-Holstein system, North of the Hambourg-Lubeck line.

* * *

As regards investigations into the profitability of *traction by means of Diesel engines,* conditions are unfortunately less definite than in the case of electric traction, seeing that in Germany there has not yet been a great deal of experience in this field, especially in the case of large Diesel locomotives. It has been and still is necessary to make use of estimates or studies which have appeared in the technical press abroad.

The data which follow are necessarily limited to the introduction of Diesel locomotives, because the question « train hauled or motor vehicle » cannot be discussed sufficiently within the framework of the present article. We will examine the present position basing ourselves upon the different points which should be taken into account in investigations into profitability of this sort.

The *cost of a Diesel locomotive* is now sufficiently well known since ten experimental V 80 locomotives and five experimental V 200 locomotives (1) have been purchased. In American publications, the ratio between the cost of a steam locomotive and a Diesel locomotive is given as 1 : 2; in Germany, for 2 000 HP it is 1 : 1.3. The corresponding ratio for electric locomotives is 1 : 1.4 though it should be noted that the type E 41 locomotive which was used for the comparison develops 40 % more power. The difference in cost between steam and Diesel locomotives is therefore not as great in Germany as it is in the United States, which seems likely to be due to the lighter construction, with hydraulic drive, which has been developed in Germany.

The *economic life* of a steam locomotive is 35 (express locomotives) to 40 years. From the financial point of view, there seems to be no reason why Diesel locomotives should have a shorter life than steam locomotives. Their replacement before this date could only be necessary and opportune if very important technical progress had been made in the meantine.

The *possible user* (availability during the 24 hours of a day) of a Diesel locomotive is, as in the case of the electric locomotive much greater than that of a steam locomotive. The number of locomotives needed to work the same volume of traffic is therefore less, which is expressed by indicating the number of steam locomotives which can be replaced by an electric or Diesel locomotive. Here again the fact that an electric locomotive is capable of hauling heavier trains must be taken into account, since the number of trains required daily and therefore the number of locomotives needed is less, and also there are differences in the time they are out of service for repairs. The increased availability is only of value if it can be taken advantage of. There must be services to profit by the increased availability! This is a fact which is often overlooked, so that figures are quoted in the technical press which are completely unrealisable on the Bundesbahn. From the economic point of view it would be nonsence to increase the mileage worked by the Diesel locomotives simply and solely to take advantage of their increased availability without there being any need for this as far as the traffic is concerned. Moreover the actual average daily user of 13.4 h per working day for the steam locomotives and 14 h for the electric locomotives, is enough to show that there is no transport demand which would make it possible to take full advantage of the approximately 23 h availability of electric locomotives. The services worked by the motor units are all drawn up by the same specialists for all methods of traction and there is no reason to suppose that in the case of electric locomotives they have displayed less zeal in making the best possible use of them. The ratio of locomotives required with the different types of traction also depends upon the specific mileage run by the steam locomotives to be replaced. If this is very great, as it is on the Deutsche Bundesbahn, this is one more reason why there is no hope of getting such high ratios as those perhaps obtained elsewhere. In the United States, the ratio is given as 2 to 1, a figure which constantly decreases as dieselisation progresses, until it ends as 1 to 1.

If the *locomotive requirements* are taken as the basis of calculation, the average daily mileage of the steam locomotives, i. e. 232 km (143 miles) (July 1954) and that of the electric locomotives, i. e. 349 km (216 miles), as well as the difference in time out of service for repairs, which is respectively 18.0 and 12.8 %, it will be seen that the ratio of locomo-

(1) The symbol for a Diesel locomotive is a V (Verbrennungsmotor [thermic engine]) followed by a figure which means the power of the engines divided by 10.

tive requirements is 1.4 to 1. In this comparison, the steam locomotive suffers the disadvantage that its mileage includes 18.5 % for shunting and local jobs which restricts the average daily mileage, whereas the specific mileage of the electric locomotive, on the other hand includes 95 % of actual passenger or freight haulage. It should not be forgotten on the other hand, that the present daily user of the electric locomotives on the Deutsche Bundesbahn is not satisfactory, and will not improve until longer sections (Hamm-Bâle, Francfort-Passau) and circular routes (Munich-Ratisbonne-Francfort-Stuttgart-Munich) are electrified. In order to throw light upon these still rather obscure points, the traction requirements have been connected up in quite a new way, in the case of the Diesel or electric locomotives, for the whole system or for very long lines; in this way the ratios given in Table 1 below have been obtained, for locomotive requirements in the case of steam, electric, or Diesel locomotives.

TABLE 1. — **Locomotive requirements with different methods of traction.**

Proportion of motor unit mileage in locomotive-km.			
Period	Steam locomotives	Electric motor units	Diesel motor units
1950	88.2 %	8.8 %	3.2 %
July 1954	79.8 %	10.4 %	9.8 %

In the case of electric traction on the Deutche Bundesbahn, the proportion of steam locomotive requirements compared with electric motor units will always remain about 1.6 to 1, i. e. favourable, because only lines with heavy traffic are being electrified so that there will be good user of the electric units. It will be quite otherwise in the case of most of the Diesel units which will be allocated preferably to services on lines with little traffic and for shunting. Here, the ratio will only be 1.5 to 1 in the case of certain types of services, for example the important passenger services. In most cases, it will be much lower, and in the case of the small railcars, as well as shunting services, it will fall as low as 1 : 1.

* * *

Labour requirements *for current maintenance* in the electric and internal combustion engine sheds is about 45 % lower than in the case of steam locomotives of the same power. In addition, less costly installations are required (no coal to be loaded, no pricking, no washing). Using Diesel engines to work the secondary lines will also make it possible to do away with satellite sheds and installations. As a whole, therefore, the service in the sheds is appreciable less costly and takes less time.

The *cost of repairs* to Diesel locomotives is an important factor that is still not very clear. On the Deutsche Bundesbahn, in 1953, the average cost of repairs for each unit in service for the different types of traction was : 11 % of the cost of replacement for the steam locomotives, 5 % for the electric locomotives and 26 % for the Diesel locomotives. Out of the 150 Diesel locomotives owned by the Bundesbahn only 15, however, are of up-to-date types of more than 360 HP; most of them are old types, much worn, of 220 and 360 HP. Consequently 26 % of the replacement cost cannot in any way be taken as the cost of maintenance for up-to-date Diesel locomotives especially for those of high power. According to information received from America, relating to heavy Diesel-electric locomotives, the annual maintenance costs for each engine in service vary between 16 and 20 % of the cost price. Even this figure seems to be very high as far as Germany is concerned. According to

theoretical studies, it would appear that the maintenance costs, in relation to the mileage worked, will not be higher but on the contrary appreciably lower than those for steam locomotives. This is why when making an economic comparison, no advantage must be given to Diesel traction from this point of view to start with.

The period Diesel locomotives are *out of service for repairs* will in all probability be less than in the case of steam locomotives, because it is often possible to exchange complete components, which reduces the repair time; the production and transmission gear is easy to dismantle.

* * *

One essential factor in estimating the economy of Diesel traction is the *consumption of fuel oil* by the Diesel locomotives, compared with the consumption of coal by the steam locomotives for the same performance, as well as the *ratio between the price of the two kinds of fuel.* At first, there was no accurate information available about consumption. According to American technical publications, the ratio between the consumption of coal and Diesel oil was about 8 to 1 on train services and 17 to 1 on shunting services. As it was found when checking these latter figures in the United States, that this very favourable ratio was attributable to the very high coal consumption of the shunting engines, the Deutsche Bundesbahn during recent years has made comparative trials with Diesel locomotives of their own or belonging to other owners in order to ascertain the consumption ratios, which depend partly on whether the specific consumption of coal on the steam locomotives to be replaced is very low, as it is on the Deutsche Bundesbahn, or high.

During these trials the types of locomotives listed in Table 2 were tried out in service by the Deutsche Bundesbahn and compared with types of steam locomotives used for the same services. In this way, the ratio between the specific consumption of coal and Diesel oil in tons per million gross tkm for the train services was found to be 6 to 1, and per 1 000 km/locomotives in shunting services 10 to 1. The most favourable ratio for the train services was 6.9 to 1 in the case of an express train service. In the case of the shunting locomotives, the consumption ratio of 10 to 1 is based on the assumption that too heavy a Diesel locomotive will not be used for the service in question; otherwise the ratio will fall to 5 to 1.

The Vt 95[3] railcar fitted with a 135 HP Diesel engine compared with a small steam train hauled by a series 74[4] locomotive in the case of a stopping passenger train gave a consumption ratio of 40 to 1 in round figures.

In all these trials, the types of Diesel locomotives used were found to be very suitable in practice and worked very well.

Finally, the long distance express train 41/42 « Senator » Francfort-on-Main-Hambourg-Altona and back, which are normally worked by fast railcars, for several days in succession were worked by rakes hauled by different types of locomotives, and by two types of Diesel railcars, in order to ascertain the consumption ratio between a train hauled by a Diesel locomotive and a Diesel railcar for light rakes on fast services. According to these trials, the consumption (in tons per 1 000 km run of the motor unit) of coal for the series 01 steam locomotive, compared with the consumption of Diesel oil were :

a) for the Diesel hydraulic locomotive V 200 :
in the ratio of 6.8 to 1;

b) for an American Diesel-electric locomotive of 1 600 HP :
in the ratio of 6.2 to 1;

TABLE 2. — **Comparison of trials between Diesel locomotives and steam locomotives.**

Axle arrangement of the locomotive	Weight in tons of the locomotive	Power of the Diesel HP	Speed of rotation of the Diesel r.p.m.	Transmission	Builders	Owners	Used on the same service as steam locomotives: series	Used on the same service as steam locomotives: type of service
B'B'	60	1 000	1 500	hydraulic	Krauss-Maffei MaK, Kiel	DB	38^{10}	passenger stopping train
$D_0 + D_0$	150	2 × 940	700	electric	Krupp	DB	44	freight
B'B'	74	2 × 1 000	1 500	hydraulic	Krauss-Maffei	DB	38^{10} 50 01	stopping trains freight fast and express trains
B'B'B'	96	2 × 1 000	900	hydraulic	Krupp		50	freight
C'C' (metre gauge)	78	2 × 950	900	hydraulic	Machinenfabrik Esslingen		—	—
$B_0'B_0'$	74	1 310	835	electric	General Motors, lent by Henschel & Sohn		23 50	stopping trains freight
$C_0'C_0'$	109	1 600	800	electric	General Motors	American army	55^{25} 50 01 03^{10}	shunting freight fast and express trains express trains
C	41.5	360	750	hydraulic	MaK, Kiel		89^{70} 92^{0}	shunting
C	45	575	750	hydraulic	MaK, Kiel		93^{0} 86	shunting stopping trains
D	52	575/650	750	hydraulic	MaK, Kiel		38^{10}	stopping trains
D	52	800	750	hydraulic	MaK, Kiel		74^{4}	stopping trains
B'B'	74	2 × 800	750	hydraulic	MaK, Kiel		03	through trains, fast and express trains

c) for a triple Diesel railcar Vt 08[5] of the Bundesbahn (1 000 HP) :

in the ratio of 11.3 to 1;

d) for the Diesel motor day train 10 501 of the Deutsche Bundesbahn (motive power 640 HP);

including the Diesel oil required for the air conditioning plant (250 HP) :

in the ratio of 9.3 to 1;

without the Diesel oil required for this plant :

about 12.9 to 1.

The ratio of cost for equal weights of coal and Diesel oil for a Diesel unit at the present time is 1 to 5 on the Bundesbahn. Consequently, for such a price ratio, if the use of Diesel traction makes it possible to replace more than 5 tons of coal by one ton of Diesel oil, fuel consumption costs are lower for Diesel traction than for steam traction.

* * *

As regards the *supply of fuel for Diesel engines* and *the cost thereof,* it should be noted that in 1953, 21 % of the Diesel oil used in Germany was imported. Of the remainder, 27 % was produced in German refineries from German crude oils and 73 % from imported crude oils. It can be taken that even if consumption increases, this ratio will remain unaltered. The power « Diesel fuel » is therefore not solely national, unlike electricity. It is also possible that the supplies of Diesel oil, as well as its price, might be threatened by political events or various political economic measures. This is not as yet very important as far as the Deutsche Bundesbahn is concerned; seeing that in 1953 its railway Diesel services only consumed 32 400 t. i. e. 1.5 % of the total consumption of the country (2 187 million tons).

The output of the refineries for the production of Diesel oil from crude oil is limited. In Germany, during the year 1954 about 27 % of the crude oil refined was turned into Diesel oil and 73 % into other products. If the production of fuel for Diesels increased and no new outlets could be found for the also increasing production of these other products, this might also limit the production of Diesel oil. In this case, the only thing to do would be to import larger quantities of Diesel oil.

It is technically possible, however, to overcome all these difficulties by making fuel for Diesel motors from coal by hydrogenation or synthetically. It is still however very costly to use these methods and they are not justified economically for railway services. The manufacture of Diesel oil from crude oil is already so costly that this product is exempt from the duty on mineral oils.

It must also be admitted that the selling price of Diesel oil produced from coal — without the duty on mineral oils — could not be less than 600 DM per ton. Such a high price can be understood when it is realised that for each ton of oil manufactured by the Fischer-Tropsch method about 9 t of coke and coal must be used as raw material, which themselves cost about 500 DM. Now, it is possible to get a much lower price than this. In the electric power stations instead of « burning » coal, it is possible to use by-products from treating the « raw material » coal. The railways can use the heavy oils obtained in the manufacture of liquid fuels on their steam locomotives as a supplementary fuel. It is also possible to add « semi-coke » to the coal briquettes used as fuel on the steam locomotives. Trials carried out by the Deutsche Bundesbahn, using briquettes containing a certain percentage of cinders from the smoke box have given satisfactory results. Finally, it is to be expected that the manufacturers will make Diesel engines which can run on heavy oils. Promising beginnings have already been made in

this direction. It would be a good thing if competent technicians would investigate whether progress in this direction would in the long run complete the present methods of buying fuel.

The price of Diesel oil, tax included, has been considerably reduced since 1950. An increase in the tax on mineral oils or a change in tanker rates would make it rise again. It is therefore necessary to allow for a certain fluctuation in the cost of Diesel oils when making financial calculations.

Compared with Germany, the ratio between the cost of coal and Diesel oil are generally more favourable abroad; from the price at the factory, not upon the traction vehicle, they amount to :

in Germany	1 : 5.9
in Holland	1 : 2.6
in Italy	1 : 2.1
in Belgium	1 : 2.8
in Sweden	1 : 2.8
in Switzerland	1 : 3.5
in England	1 : 3.3
in Austria	1 : 5.2

* * *

As the service trials of the big Diesel locomotives showed, in practice one horse power in steam traction cannot be taken as the equivalent of one horse power in Diesel traction. At the lower speeds, the Diesel locomotive is superior to the steam locomotive on account of the fact that its power can be better utilised and consequently a definitely higher tractive effort is available than in the case of a steam locomotive of the same power. This is because the adhesive weight of Diesel locomotives (weight in running order = adhesive weight) and the coefficient of adhesion between wheel and rail are higher. The power of the steam locomotive on the other hand depends upon the skill, physical capability and willingness of the stoker, as well as upon the quality of the coal. The fire has to be regulated for a certain time before the power is available. In the case of the Diesel locomotive, the total power is always immediately available; neither physical effort, skill nor good will are required. Consequently the Diesel locomotive is better than a steam locomotive of the same power in actual service, and the more so as there are more stops or when the whole power of the engine has to be used more often.

In addition with Diesel traction — like electric units — the fitting of a safety device, the fact that driving involves less physical effort on the part of the driver and that his attention is not so distracted by physical work, makes it possible *to have only one man* in many cases. Finally the Diesel and electric locomotives are particularly suitable for working with *reversible rakes* with completely automatic control, no one being required on the rear engine, unlike with steam traction.

* * *

Experience obtained with Diesel traction can be *summed up as follows* :

a) the consumption of coal is ten times as high as the consumption of oil in the case of shunting services, and six times as high in the case of train services. What is new in this connection is that the ratio of 6 to 1 also applies to the heavy train services;

b) maintenance costs are no higher, but on the contrary probably lower than in the case of steam locomotives; time out of service for repairs is also probably lower;

c) current maintenance costs are also lower than in the case of steam locomotives;

d) the ratio between requirements with steam and Diesel units is at the most 1.5 to 1; on secondary lines 1.2 to 1 and for the small railcars 1 to 1;

e) with equal motive power, higher tractive efforts are available at low speeds;

f) only one man is needed to drive

them; they are specially suitable for reversible rakes.

g) no smoke or soot;

h) the purchase price of steam and Diesel locomotives are approximately in the ratio of 1 to 1.3;

i) simpler local installations and possibility of closing down sheds and their subsidiary installations.

This information makes it possible to draw up — still on the basis of present costs — the *following programme of practical application* for the German Bundesbahn :

1) the Diesel locomotive makes it possible to expect the greatest economic advantages compared with the steam locomotive in the case of the shunting services and on the secondary lines. Particularly important economies can be achieved with small railcars. In these cases, even appreciable fluctuations in the cost of Diesel oil will not compromise the profitability of this substitution. Consequently, it is to such services that dieselisation should first of all be applied. For this purpose 1 000 shunting locomotives and 600 locomotives for secondary lines have been budgeted for;

2) in the case of long distance passenger trains, a financial saving can also be counted upon, though a smaller one, and more likely to be affected by fluctuations in costs. But as competition and satisfying the public are on the side of the Diesel (no smoke or cinders, good acceleration on starting, good outward appearance), because such traffic is relatively small and finally because the stock of express steam locomotives is getting rather old, the adoption of powerful Diesel locomotives for the long distance express train is advisable. For these services at least 200 Diesel locomotives will be required, which is a chance for German industry to design and test out powerful Diesel locomotives in the interests of the export trade;

3) shunting services in the small yards and small shunting jobs are the proper field for the Diesel-hydraulic locotractor. For this purpose, a stock of about 1 000 engines of the Kö II type are budgeted for, of 107 HP;

4) all the very light services (small railcars) will be reserved for the Diesel railcars, short distance services with many stops and starts and high speed passenger services at more than 140 km (87 miles)/h, which means introducing railcars in every case where a light weight unit and high specific power of the engine is of importance, where fairly regular user can be counted upon;

5) this *dieselisation programme* budgets for a final stock of :

1 900 Diesel locomotives,
1 000 locotractors,
250 large railcars, and
900 small railcars (rail buses).

In the case of the small railcars (rail buses), the section from which the most important economic saving is to be expected, 75 % of the programme will soon be realised when 672 units have been delivered, 100 of which are twin engined.

The *annual consumption* of Diesel oil for these 4 000 or so Diesel engines will be as much as 280 000 t. If it is taken that the consumption of oil for other purposes will have increased by about 30 % in Germany before this programme is completed, so that in round figures it will have reached 3 million tons, the Diesel units of the Deutsche Bundesbahn will still only account for 9 % of this total. This will still be a relatively small percentage. This programme does not therefore involve any excessive risks, especially as the change over will only be made in absolutely essential cases.

* * *

This programme for modifying the traction structure by the extension of

electric and Diesel traction is to be carried out at the same time as an improvement in the quality and a prudent renewal of the stock of steam locomotives, at the appropriate time, therefore with prudence. It is only when greater experience has been obtained in service that it will be possible to decide how this programme should be carried out.

The beginning of this changing structure can already be seen in the evolution of the last few years, as Table 3 shows.

TABLE 3. — **Proportionate use made of different methods of traction on the Deutsche Bundesbahn.**

System or line	Type of service	Type of motor unit compared	Ratio of stock required steam/new traction
Whole of the DB	Long distance light fast trains	Diesel locomotive	1.5 : 1
Ruhr-Stuttgart	Stopping and freight trains	Electric traction	1.64 : 1
Left bank of Rhine Wedau-Mayence-Bischofsheim	Freight	Diesel locomotive Electric locomotive	1.3 : 1 1.52 : 1
Munich-Stuttgart	Stopping and freight trains	Electric traction	1.49 : 1
Schleswig-Holstein	Especially for train services and shunting on secondary lines	Diesel locomotive	1.14 : 1

The realisation of the electrification and dieselisation programmes dealt with here will also lead to a considerable reduction in the *number of types of traction units*. The types will probably be reduced to :

In the case of steam locomotives	From 50 to 7
In the case of electric locomotives	From 22 to 4
In the case of electric rail motor coaches	From 22 to 2
In the case of battery railcars	From 6 to 2
In the case of railcars with internal combustion engines	From 35 to about 8

Whereas the types of Diesel locomotives will remain at 6.

The renewal of engines will therefore only involve 30 types instead of 140.

The question which arises at the present time is the following : « Are there already any types of Diesel locomotives entirely suitable for operating requirements in order that this programme can be carried out with 1 900 locomotives ? » This can be answered in the affirmative, as two of the Diesel locomotives designed for the Deutsche Bundesbahn, the V 200 and the V 65 have been so successful that

the prototypes have given complete satisfaction in service.

The V 200, a B'B' Diesel locomotive of great power, with two 1 000 HP engines and hydraulic transmission (2) has been designed by the firm of Krauss-Maffei in collaboration with the Central Office of the Bundesbahn at Munich, with the collaboration of the firms of Henschel & Sohn, Krupp, Maschinenfabrik Esslingen, Jung and MaK of Kiel, as well as the builders of Diesel engines and transmissions. It is suitable for all kinds of train services, and has a maximum speed of 140 km (87 miles)/h.

The Diesel-hydraulic D locomotive type V 65, designed on its own initiative by the firm of MaK, at Kiel, has two Beugniot bogies and a 650 HP Diesel engine; it is intended for service on secondary lines and shunting, and has a maximum speed of 30/75 km (18/46 miles)/h (3).

The B'B' Diesel-hydraulic locomotive type V 80, 10 of which have been acquired to date (4) will be built in the future in a smaller form, type V 100, with a motive power of 1 000 HP and a maximum speed of 50/100 km (31/62 miles)/h. This will be used on secondary lines with heavy traffic, for heavy shunting services and in suburban traffic, being designed above all to work reversible rakes. After a fairly long trial period, this locomotive also has been found very satisfactory in service.

Another series will be the V 60 for shunting services only. The designs have been completed and 300 units are to be ordered to start with. This is a Diesel-hydraulic C locomotive, driven by stub axles (faux-essieux et bielles), and connecting rods with which different types of engines can be used. This locomotive is intended solely for shunting services and is not suitable for train services. As all the components used have been proved in service over a long period no trouble should be experienced with this type.

Finally, studies are in hand for a Diesel-hydraulic locomotive of 1 500 HP and 2 × 1 500 HP for train services on main lines.

* * *

After this vast *programme* which we have reported, the Deutsche Bundesbahn will have taken a new step forward in the traction field towards the end it has in view : the rationalisation and modernisation of its operating equipment.

(2) *E. T. R.*, 1953, No. 6-7, pp. 275 to 288.

(3) *Lokomotiv- und Werkstättentechnik*, 1954, pp. 3 and following.

(4) *Glasers Annalen*, 1952, No. 4, pp. 72 and on, and *E. T. R.*, 1952, No. 8, pp. 265 to 272.

[656 .1 (44) & 656 .211 .5 (44)]

Connecting road services at Caen,

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(*Revue Générale des Chemins de fer*, January 1955.)

Since 1938, there has been a central coach station in Caen in the centre of the town, operated by the Courriers normands. The site it occupies, in the angle between two streets (fig. 1) is relatively small, but the fullest possible use has been made of it. The interior arrangement has been carefully studied, both as regards the movement of passengers on arrival and departure, the handling of luggage, the circulation of the coaches and their arrival at the platforms which is regulated by light signals and loudspeakers.

Fig. 1. — The central coach station.

This station escaped the great damage the town suffered in 1944. It was therefore natural to keep it as the main coach station after the war. But its distance (about 1 500 m = 1 640 yards) from the S. N. C. F. station in the centre of the town (fig. 2) soon made it obvious that it would be extremely valuable to set up a road service at this latter station to facilitate the transhipment of passengers and luggage from the trains to the coaches and vice versa. The need was the greater owing to the fact that after the war traffic was not restored on the narrow gauge line between Caen, Riva-Bella-Lion-sur-Mer, and in 1951 the standard gauge services from Caen to the sea were given up. At the same time, this stopped the through service by rail for the many Parisians who freqent the Côte de Nacre in the summer.

As far back as 1943, the S. N. C. F. studied the possibility of setting up con-

necting road services closer to their own passenger installations. The most rational solution appeared to be to make use of the old parcels office and the yard in front of it (fig. 3) which was available owing to the changes made in the parcels traffic, resulting in all this traffic being dealt with in the old slow goods depots.

the site in question, especially the cost involved in demolishing the parcels office.

In addition the setting up of the connecting road services was made dependent on the usual restrictive clause intended to protect the traffic of the S. N. C. F. should the services be extended to freight services. Finally, the S. N. C. F. obtained

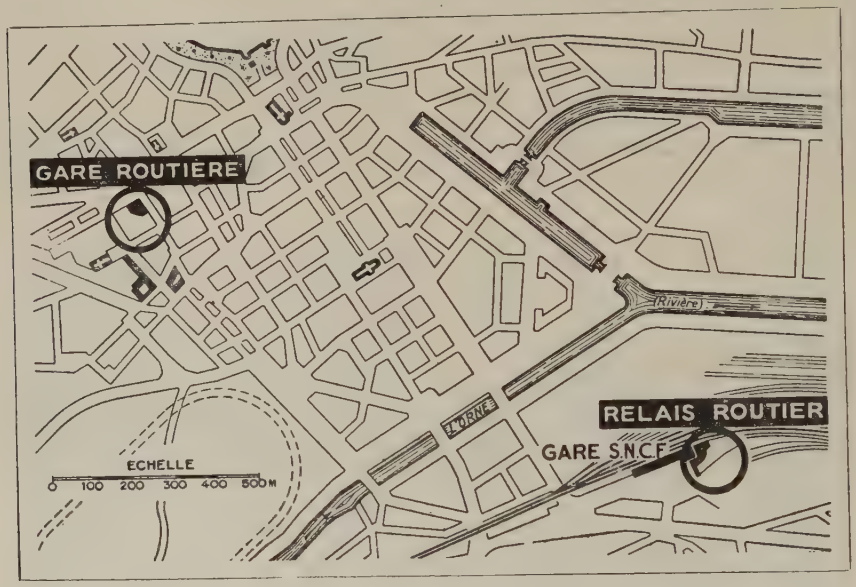


Fig. 2. — Part of the map of the town of Caen.

A site of 5 115 m² (6 117 sq. yards) was therefore offered to the Department, which, on the 25th August 1952, received the necessary sanction from the Ministry as laid down in the ordinance of the 24th October 1945 relating to coach station. The negociations between the S. N. C. F. and the General Council through the intermediary of the Chief Engineer of Roads and Bridges were successfully concluded. The agreement arrived at was that the site in question was handed over free of charge to the Department by a change of user of the Public Area. The Department stood the cost of this transfer; they repaid the S. N. C. F. part of the cost of arranging for the catering firm of the station of Caen the monopoly of catering for the road services.

The installations for these services, which are run by the Courriers normands include (fig. 4) a yard for the coaches and a passenger platform adjoining the main building of the S. N. C. F. station. Bays have been made in this platform to allow 14 coaches to draw up at the same time, but only part are covered, corresponding to the area normally used, apart from the summer months. The actual building has an area of 130 m² (154 yards), faces the station yard and consists essentially of a hall for the public, a ticket office and a luggage office.

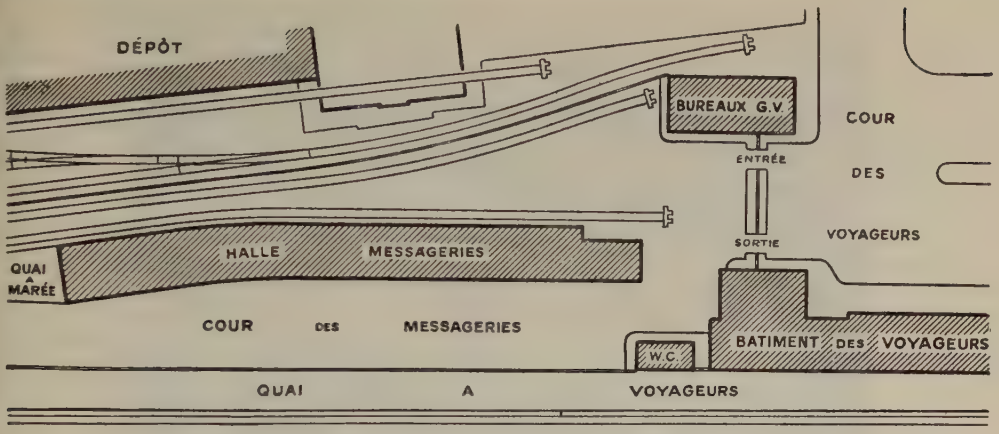


Fig. 3. — Ancient arrangement of the installations.

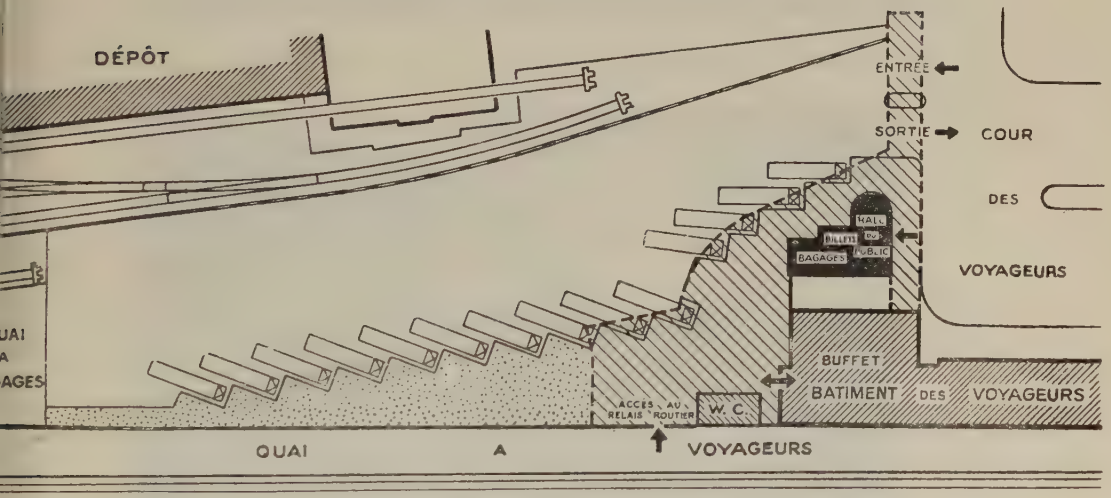


Fig. 4. — New arrangement, with the coach station.

Figure 5 is a photograph showing part of the station before it was covered in; it can be seen that passengers alighting from a train from Paris have only to pass through the barrier to get to the coaches which are waiting in the bays.

At the end of the yard used by the road vehicles, there is a high platform used during the holiday season for transhipping luggage from the lorries of the Courriers normands to the luggage vans of the S. N. C. F.

These new arrangements were used for the first time at the beginning of the summer of 1953 although the work had not yet been completed.

In normal times, out of the 150 coaches which run each day from the main coach

Fig. 5. — Passengers getting from a train to the coaches.

Fig. 6. — Passengers getting ready to take their seats in the coaches drawn up in the bays of the connecting coach station.

station, 88 serve the connecting station, while a similar number are run in the opposite direction. In the summer, these figures increase from 88 to 102 out of the 182 coaches from the coach station to which some 30 supplementary coaches must be added on peak days.

The following figures give some idea of the amount of traffic at the station and its variations over the year.

Month	Number of passengers leaving the coach station	Percentage compared with number of passengers leaving the central coach station
February 1954	9 500	8 %
August 1954	34 200	23 %

The following example shows that this station is able to cope with very heavy passenger traffic (fig. 6). On the 1st July 1954, between 11.35 a. m. and 12.15 a. m. out of 39 coaches from the station, 24 carried 1 284 passengers from the railway travelling to the beaches of the Côte de Nacre.

This brief report shows that the simple installations built on the premises of the S. N. C. F. have made it possible to achieve a harmonious link between rail and road, with the maximum convenience for passengers.

[625 .28 (73)]

Passenger stock developments in U.S.A.

Lightweight articulated trains 11 ft. high, and Hi-Level double-deck stock 15 ft. 6 in high.

(The Railway Gazette, August 5, 1955).

Plans have been made public concerning a number of trains of entirely new design now on order for U.S.A. railways. The starting point of the various ideas is the Talgo type of train, with lightweight coaches considerably lower in height above rail than normal American stock, and a lower centre of gravity, which will make higher speeds round curves safely possible, though not all the trains on order are of the articulated Talgo type.

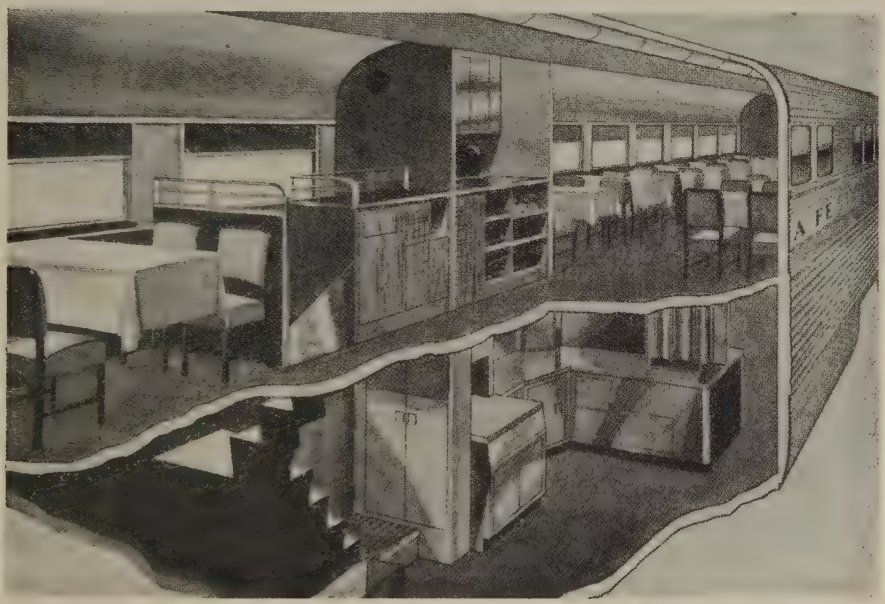
The New York, New Haven & Hartford Railroad has, however, placed a contract with A. C. F. Industries, Inc., for a Talgo train, of which delivery is expected in the latter part of this year. It will consist of five coaches, each of three articulated units, seating in all 400 passengers and powered by two 1 200 HP Diesel-electric locomotives, and with an extra « transition » car to provide for third-rail electric operation into and out of the Grand Central terminal at New York. The train will be marshalled with one locomotive

Atchison, Topeka & Santa Fe Railway double-deck Hi-Level chair car built by the Budd Company.

at each end. The car floors will be 26 in. above rail, instead of the usual 54 in., and the centre of gravity of each car will be about 2 ft. lower than normal. The weight per passenger will be about half that of conventional equipment. This train will be similar to that already on order by the Chicago, Rock Island & Pacific Railroad for its « Peoria Rocket » service.

engine mounted on a four-wheel bogie and operating through a four-speed torque-converter transmission; an additional six-cylinder Diesel engine of 400 HP will provide light, heat and air-conditioning for the train.

It is not stated how many vehicles there will be in the train, or what its accommodation; as with the Talgo train, one locomotive will be attached at each end,



Cutaway view of Santa Fe Hi-Level restaurant car to run in « El Capitan » between Chicago and Los Angeles, with accommodation for 80; food is brought up by lift from kitchen on lower deck.

Pullman lightweight trains.

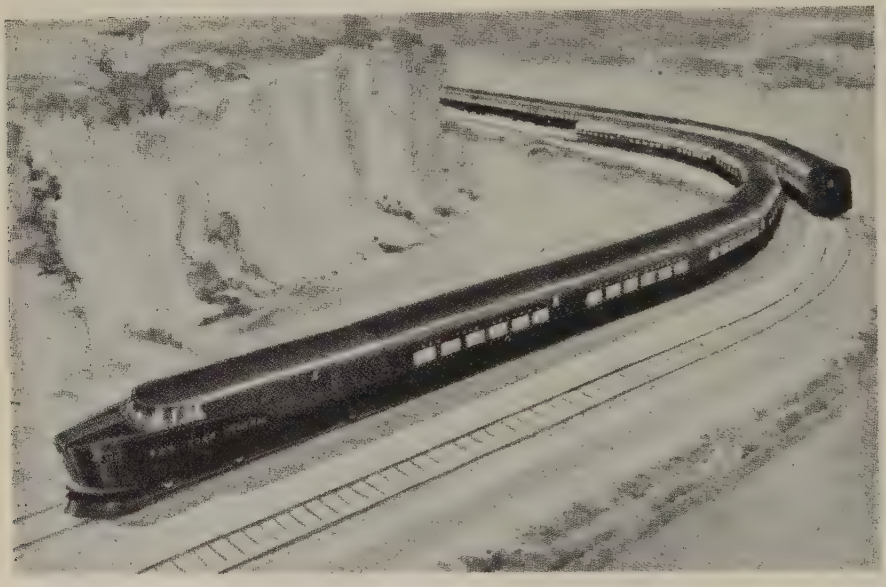
For comparative trials, the New Haven also has ordered a new lightweight passenger train of revolutionary design from the Pullman Standard Car Manufacturing Company, with Diesel locomotives to be built by the Baldwin-Lima-Hamilton Corporation. Each locomotive will be 11 ft. high only, and 46 ft. long, and will weigh about 70 tons; power will be provided by a 1 000 HP 12-cylinder Diesel

and the weight and cost of the trains, relatively to their accommodation will, it is claimed, be no more than one-third that of conventional equipment. A similar train is on order for the New York Central System, and this company also has expressed its readiness to purchase one of the new General Motors lightweight trains when these become available. It is expected that the first of the latter will be tested on the New Haven main line later this year.

Pennsylvania « Tubular » train.

A fourth variation is the « tubular » train which the Budd Company is now building for the Pennsylvania Railroad, and which is of a totally different type. It will consist of seven bogie coaches, each 85 ft. long, but with what is claimed will be lowest centre of gravity ever planned for passenger vehicles, 42 in. above rail. Each car will be 11 ft. 9 in. high, and will weigh less than 35 tons, a reduction of some 40 % on existing coach weights. One of the methods of lightening the vehicles is to design the roof, sides and floor of the tubular structure in such a way that they provide the strength of a normal car underframe. The lowered centre of gravity should permit an increase of at least 15 % in the highest speeds scheduled at present.

Each car will accommodate 82 passengers in reclining and lounge chairs, to a total of over 500 in a total coach weight of just under 250 tons. Light refreshment facilities will be provided, with other usual amenities. Existing electric and Diesel-electric locomotives will be used, and it is intended to use the train on daylight runs between Pittsburg and the cities of the eastern seaboard, such as Washington, Baltimore, Philadelphia and New York. The set of seven coaches is expected to cost a little over $ 1 000 000.



Artist's impression of trains with low centre of gravity ordered by the New York Central System from the Pullman Standard Car Manufacturing Company, with locomotives built by the Baldwin-Lima-Hamilton Corporation.

By contrast, the Atchison, Topeka & Santa Fe Railway is going to the opposite extreme. For some time this company has had in operation one or two Hi-Level coaches on its Chicago-Los Angeles service, in which the entire seating is on a level 4 ft. above that of a coach of normal design, the depressed lower centre level of the car being used for entrance vestibules, lavatories, luggage lockers, etc., and the

ends, above the bogies, for housing air-conditioning and other equipment. By this arrangement, the entire upper level of each car is available for seating, with 28 more seats than in an ordinary 85-ft. chair coach; passengers enjoy the more extensive view obtainable from their elevated position, 8 ft. above rail; and it is claimed that noise and vibration are reduced. The success of these experimental cars has been such that the Santa Fe has decided completely to reequip its « El Capitan » all-coach streamliner between Chicago and Los Angeles with cars of this type each 15 ft. 6 in. high.

For the five trains needed to maintain this service 47 Hi-level cars are on order — 35 reclining chair cars, six dining cars, and six full-length dome lounges. In the dining cars. the upper level will be devoted entirely to dining space, with 80 seats, and the kitchens and pantries will be on the lower level, with service lifts between the two levels. The dome lounges, at the rear of each train, will seat 88 passengers on two decks, and will be provided with rest rooms and a refreshment bar. Each train will be made up of nine vehicles, and the seven reclining chair cars will accommodate a total of 496 passengers, as compared with 350-passenger capacity of the present « El Capitan » trains. A public adress system will broadcast music, radio programmes, and train announcements.

[621 .431 .72 (73) & 625 .28 (73)]

GM building complete high speed train.

New locomotive and new cars being turned out by GM divisions feature new concepts, but GM is not to become a car builder.

(*Railway Locomotives and Cars*, August, 1955.)

Harlow H. Curtice, president of General Motors Corporation, has revealed specific details of the lightweight, low-cost passenger train his corporation was known to have been building. He termed the train a « new concept » in railroad transportation. It will have a capacity of 400 passengers and will be able to operate at speeds over 100 m.p.h. for sustained stretches. It will be shown to the public sometime later this year and thereafter will be demonstrated on all major railroads, he said.

The train will consist of 10 coaches and a single 1 200-HP Diesel-electric locomotive. It will cost less than $ 1 000 per seat when built in volume production. Mr. Curtice predicted.

Model indicates the relative size of the locomotive and the cars, and shows the single two-wheel idler axle which will sustain weight at the rear of the locomotive. One 12-567 C GM Diesel engine, mounted conventionally inside the 53-ft locomotive, will furnish 1 325 HP for traction. Current for train heating, lighting and air conditioning will be furnished by generators operated by two GM 6-110 Detroit Diesel engines, also mounted within the locomotive body. Top of the cab will be 13 ft, 7 in. above rails. Some details may vary slightly in the final version of the train, which was shown at the General Motors « Powerama », August 31 in Chicago.

Light weight cars.

The car bodies will be comprised of steel carlines and purlines over which will be laid an exterior sheathing (above the floor) of anodized aluminium. Below floor level, the sheathing will be steel of a similar pattern.

Because the new type of car body is so low in first cost, it is expected, according to GM spokesmen, to prove more economical to discard a worn-out body and replace it with an entirely new body on the old underframe, than to put the old body through the present expensive practice of rebuilding.

dead air and 2 in. of Fiberglas insulation. The floor itself will be of 7/8-in. exterior plywood, topped by a 1/8-in. rubber mat. The seats will be bolted through this and direct to the steel subflooring.

One end of each car will have a vestibule with entrances on both sides. Fold-

A sand-bagged test coach minus superstructure, shows binlike construction in underframe. Compartments, from left to right, are for vestibule step, truck, air brake equipment, baggage (2), air conditioning equipment, truck and water storage tank. Attached beneath each tightlock coupler will be a box containing all connections needed for air, steam and electric lines. These connections will join automatically upon impact, thus eliminating the need for « coupling up » air and steam lines.

The GM coaches will have a welded steel underframe, so designed as to carry strength out to the sides for maximum safety. A 3-in. space will separate the steel subflooring — an integral part of the frame — from the flooring in the passenger compartment of the cars.

Within this space will be 1 in. of

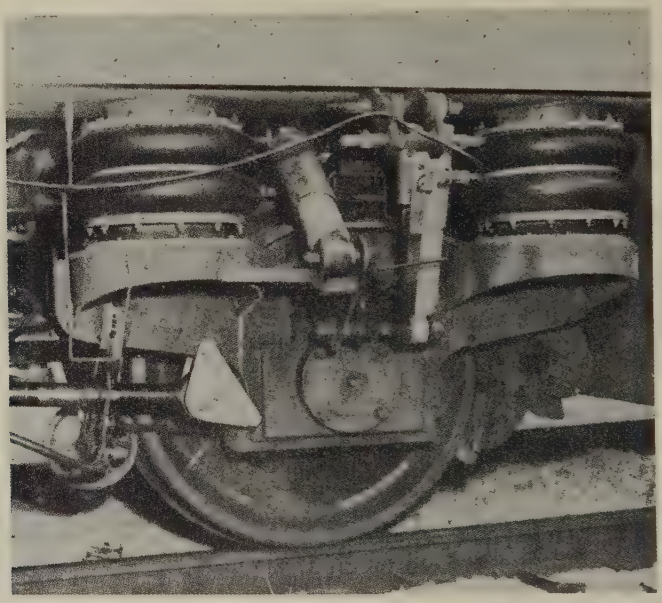
ing steps are designed to accommodate passengers at both high and low platforms. The other car end will contain a lavatory and an airplane type pantry able to serve up to 40 meals.

Baggage will be carried in compartments under car floors Thus, while passengers will ride on a higher level,

the center of gravity of the coaches will be 10 in. lower than in present railroad equipment.

Exterior styling and interior decor have been worked out by the GM styling section. Strength and safety features will be « far in excess » of government and railroad requirements, Mr. Curtice said.

The air suspension system will help insulate the coach body from noise and shock of steel wheels on steel rails. This system also aims to provide self-compensation for body variations due to load changes, centrifugal force on curves, etc., thereby providing a level ride. A separate air line from the locomotive feeds the system. An outside rubber cap pedestal mounted between the bellows will support the car body in the event of damage to the bellows or loss of air pressure for the suspension system. The shock absorbers are planned to help dampen lateral and vertical motion.



Revolutionary truck has single axle and bellows-type air suspension in lieu of conventional steel springs. This is but one of several types being tested by GM engineers; here, it is draped with wires, cables, etc., connected with recording instruments.

Air springs.

Cars of the new train are adapted from the body design of GM's Truck & Coach division's 40-passenger intercity type highway coach, but are widened 18 in. to give more seating space in the cars and a wider aisle. Like the highway coaches, the cars will have air, rather than spring, suspension and many of the suspension parts will be interchangeable with those used in standard « sceni-cruiser » highway buses.

Because the locomotive will have a dynamic braking system, which GM expects will meet all requirements except holding the train stationary and for

emergencies, the composition-shoe single brake on each car wheel will be so seldom used that, GM believes, it should last the life of the car.

Mr. CURTICE explained that the train was designed to meet requirements set by a group of railroad presidents who asked car and locomotive builders to explore new ideas in equipment design to cut investment, reduce operating and maintenance costs, lower the center of gravity, increase average speed, improve riding comfort and help reduce the railroad passenger deficit.

Designed as unit.

The committee's challenge gave GM a chance to design an entire train as a unit, said Mr. Curtice. « Here, for the first time, was an opportunity to select the most economical prime mover and match it with a train to obtain the ultimate in utilization and economy, » he explained. « The size of the Diesel engine, the size of the auxiliary engines, the size and weight of the cars, for example, have been determined by the contribution each makes to the most successful whole, from the standpoint of performance, first cost, operating cost, maintenance, repair costs and safety, » he said.

To the requirements of these railroad presidents, GM added one of its own — that existing, proved components should be used in the new train wherever feasible. Because these are already in mass production, this means economy, and because they have been long tested, it means reliability, he stated.

Thus, the new train will have standard GM Diesel engines and Electro-Motive generators, traction motors and control apparatus. Car bodies, as stated, will be from GM's Truck & Coach division; air conditioning from GM's Frigidaire division; auxiliary Diesel engines for train heating and air conditioning from the Detroit Diesel Engine division, and auxiliary generators from the General Motors Delco Products division, Mr. Curtice explained.

1 200 HP locomotive.

The locomotive will contain a single 12-cylinder GM Diesel engine offering 1 200 HP for traction. Fuel consumption will be about 1.3 gal. per mile at top speed with full load on level track. The lighter weight and lower center of gravity will permit faster average operating speeds than is possible with present streamlined equipment, Mr. Curtice predicted.

« General Motors has no intention of going into the railroad passenger car building business », he reiterated. « It is primarily interested in the promotion of the use of its Diesel motive power and presents the new cars as a service to its customers in the hope that they may offer a solution to the passenger deficit problem. »

The new train will be « even more startling » than the GM « Train of Tomorrow » built several years ago, he added.

[656 .254 (73)]

More efficient railroading... Modern signaling = Fewer tracks.

For each track mile removed, railroads can avoid expenditure of $30 000 to lay new rail; get $4 500 to $10 000 salvage value and save about $3 000 annually on maintenance,

by John H. Dunn,
Associate Editor.
(*Railway Age*, July 11, 1955.

One track, with modern signaling, now serves where two were formerly required.

Recently, the railroad industry received the impressive news that the New York Central will remove, within the next 16 months, two of the four main tracks on nearly all of the 185 miles between Buffalo and Cleveland, and that it is investigating the possibility of removal of one of the two main tracks on 200 miles between Boston and Albany.

Are these projects of a nature peculiar to the New York Central? If not, what are the factors to be considered as applying on sections of other railroads? Perhaps an answer may be found in an analysis of changing circumstances, and a study of similar projects now under way or recently completed on other roads.

Modern motive power, changing con-

ditions in train operations, and new developments in signaling systems are enabling railroads to (1) move more trains over single-track lines; (2) remove one or more main tracks where two or more are now in service; or (3) get more trains over existing double track, thus avoiding construction of a third track. The objective is to avoid the costs involved in renewal of rail, fastenings and ballast where tracks can be removed, and also to reduce current expenses for track maintenance and taxes. In addition, on many of these installations, on-time train performance has been improved, and better service to the public has resulted.

Trains are now fewer and faster, compared with 25 to 40 years ago, when much of the multiple trackage now being studied was built. Passenger train speeds have been increased from roughly 55 or 60 m.p.h. to 79 m.p.h., or more. Freight speeds have increased from about 35 m.p.h. to 60 m.p.h. Diesel locomotives take on fuel only at terminals and save the time previously lost in stops for fuel and water for steam locomotives. Modern passenger and freight cars are designed for higher speeds. Better rail, ties and ballast, with improved maintenance practices, make track suitable for high train speeds. There has been a great reduction in time lost on sidings for meets under the antiquated system of authorizing train movements by timetable and train orders.

Considering these and other factors, the track-occupancy time of main tracks per train mile, is much less now than in years gone by. This leads to these questions, as applying to a given territory : (1) What can railroads do to handle the present traffic with fewer delays, without adding another main track; and (2) in multiple-track territory, can one main track be removed, with adequate track capacity being provided by power switches and signals in a CTC system to authorize train movements by signal indications ?

Time to act.

A logical time to remove one of two main tracks is when the rail in one or both tracks is due for replacement. The material and labor cost of laying new rail may be $ 30 000 or more per mile of track, depending on weight of rail and other local circumstances. By maintaining one main track, instead of two, the annual track maintenance cost may be reduced $ 2 000 to $ 3 000 per mile of main track eliminated. In some states, the annual taxes per mile of main track may range up to $ 500.

In 1950 the Milwaukee was faced with the renewal of rail on both main tracks on 62 miles. By removing one track, renewing rail on the remaining track, and equipping it with centralized traffic control the road saved $ 1 500 000. In 1951 the Erie changed from double to single main track on 56.7 miles. For the project as a whole, the retirements included 47.5 miles of second main, 2.7 miles of sidings and 17 turnouts. The rail removed included 21.3 miles of 110-lb rail laid in 1926-28; 24.4 miles of 112-lb laid in 1941-48; 1.1 miles of 115-lb laid in 1948; and 0.85 miles of 132-lb laid in 1949.

Roughly, 110 000 ties, in condition for re-use in main track, were salvaged. Total salvage value was approximately $ 575 000, and the expense involved in this operation was about $ 136 200, leaving a net salvage of $ 439 100. The estimated cost of changing the turnouts and other track changes was $ 37 570, and the signal changes and additions were $ 463 347, totaling $ 500 920. Thus, the salvage of rail and ties paid all but about $ 62 000 of the cost of the entire project. The estimated reduction in track maintenance is $ 92 000 annually.

If the rail in track sections removed is good for further service, its salvage value is much more than the scrap price. When the Southern removed second track on 42 miles in Alabama, the rail was used on other divisions to release relay

rail, which in turn was used in the construction of a new yard at Birmingham. About 80 % of the ties and much of the slag ballast were also used in the construction of this yard. Special machines for taking up rail and ties were developed on this project.

Non-stop meets.

As compared with single track, the big advantage of double track is when trains of opposing directions meet. When changing from double to single track, several roads have made provisions for trains of opposing directions to meet with very little, if any, loss of time. Long sidings is one answer. In 1951 the Boston & Maine removed second track on about 22 miles out of 34 between Nashua, N. H., and Concord; sections of second main about two miles long were left in place as sidings. These long sidings increase the opportunities for trains to make running meets, in which neither train stops. In a recorded instance, a southbound train went through a siding at an average of 30 m.p.h. without a stop, while the northbound train went by on the main track at normal speed of 60 m.p.h., without a stop. At that time this territority was handling 26 to 30 trains daily.

On 107 miles of single-track on the Santa Fe between Bakersfield, Cal,. and Fresno, there are twelve 2-mile sidings, two 2.5-mile sidings with center crossovers, and two 1-mile sidings. Turnouts are good for diverging moves at 40 m.p.h. Neither train stops in about 80 % of the meets. This territory handles 8 passenger trains and 8 to 12 freights daily, with extra trains in vegetable and fruit seasons.

By running both ways on both tracks, all trains keep moving; none wait on sidings.

The Rock Island is now planning to remove second main track on about 80 miles between Topeka, Kan. and Herington. Sidings are to be 3 miles long with double crossovers to the main track near the center of the sidings. This practice is based on experience gained with similar layouts on a project in service several years between Atlantic, Iowa, and Council Bluffs. The sidings are to be about 2.5 miles long and about 12 miles apart on a project which the Grand Trunk Western now has under way to remove one track on 80 miles of double track between Durand, Mich., and Port Huron.

In, through, and out, quickly.

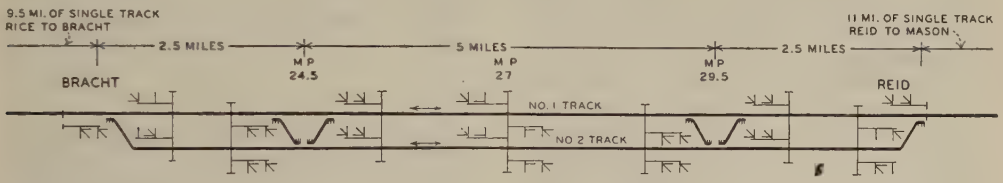
An important element in making non-stop meets is for the train which is to take siding to approach and enter quickly — i.e. at 45 m.p.h. or perhaps up to 55 to 60 m.p.h. This requires high-speed turnouts and signaling to direct enginemen to use these turnouts at the maximum speed for which they were designed. Several railroads are now using turnouts good for 45 m.p.h. and the Erie has some designed for 60 m.p.h.

Obviously, if a train is to enter a siding at even 45 m.p.h. for the entire train length, the siding must be long enough for the train to stop. This is further reason for long sidings. Also the siding must be equipped with track-circuit-controlled intermediate signals, and the limited aspect.

No sidings at all.

Sidings were eliminated entirely in a 167-mile territory on the Southern between Cincinnati, Ohio, and Tateville, Ky., formerly double track, on which alternate 10-mile sections of second main track were removed, thus leaving sections of two-main tracks about 10 miles long. In each of the two-track sections, there are two layouts of double crossovers each about 2.5 miles from the nearest end of the two-track segment, leaving about 5 miles between the crossover layouts.

On the former double track, each track was signaled; sidings, with hand-throw switches, were used for running fast trains around slow ones of the same direction. Now trains are kept moving on two-track while making meets or passes. The 22 single-direction sidings were dispensed with; thirteen were removed entirely, parts of eight were retained as pocket tracks or house tracks; and one as part of a yard. Thus the new system includes no sidings used normally for the meeting or passing of trains. This is a new way to run a railroad. During the first year this installation was in service the results were so satisfactory that the Southern is proceeding with another similar project on 70 miles.



Typical layout of switches, crossovers and signals on alternate single-track, double-track arrangement developed by the Southern.

To increase capacity of double track.

A somewhat different problem is to increase the capacity of double track to obviate the need for a third main track. For example, the 75 miles of double track on the Chicago & North Western between West Chicago and Nelson, Ill., handles 22 through passenger trains and about 16 through freights daily. The difficulties are increased because trains are bunched inbound to Chicago in the morning and outbound in the evening. During these peak periods, many freight trains were delayed on sidings or held in the yard.

The problem was solved by installing signaling for train movements both ways on each track. New high-speed crossovers are located an average of 6.4 miles apart. In the morning when the preponderance of traffic is toward Chicago, faster trains can be crossed over to the other track to run around slower ones, or slower trains can be crossed over to let faster

ones go by. In either instance, sections of track that otherwise would be standing idle are utilized to keep all trains moving at normal speed, rather than delaying slower trains on sidings. Similarly, in the evening, when the preponderance of traffic is westward, sections of both tracks are used by westbound trains. Somewhat similar systems of signaling both ways on each of two main tracks are in service on extended sections of the Santa Fe, Rock Island, Union Pacific, Frisco, Illinois Central, Missouri Pacific and Boston & Maine. Under construction now is a project on 185 miles of the New York Central between Buffalo and Cleveland, where two tracks of a four-track line are being removed. The remaining tracks are being equipped with double crossovers spaced an average of 7.3 miles apart, and each of the two remaining tracks is being signaled both ways. The project is expected to pay for itself in approximately six years by annual reduction in maintenance costs of about $ 3 500 per track mile, and annual tax savings of $ 400 to $ 600 per track mile.

Electronics now used in CTC.

In the projects mentioned above, the switches used by through trains are power operated. Signals at these switches display aspects to authorize train movements without the use of train orders. These power switches and signals in a territory, which may be an entire division of 150 to 200 miles or more, can be controlled by one machine in the office of an operator or dispatcher. This system is known as centralized traffic control.

In these systems only two line wires are required from the dispatcher's office to the remote end of the territory to transmit controls for switches and signals and to bring back information on the position of switches, aspects of signals and occupancy of each track section. Modern electronic techniques have enormously increased both the speed and the capacity of these signal control systems. These advances now make it economically practical to centralize control over extended sections of busy multiple-track main line, including interlockings. Thus, beginning with the NYC's consolidation of control on a whole division, we may look forward to many such consolidations — even to entire railroads controlled from a single headquarters point.

The New Haven is now planning a project for the 157 miles between New Haven and Boston, to include consolidated control of all the interlockings as well as signaling for train movements in both directions on each of the two main tracks. Because of hurricane damage to line wires and pole lines in this area during the past few years, the New Haven is investigating a proposal to install microwave sytems for transmission of the CTC controls and the return of indications, as well as for through telegraph and telephone circuits. Completion within the next four years is planned.

On many lines now operating fewer trains at higher speeds, investigation will show that removal of one track of double-track, along with installation of modern signaling, should save money and improve train operations.

Where better signaling means fewer tracks — a case history.

SANTA FE. — EITHER DIRECTION ON BOTH TRACKS :

Railway Age, December 19, 1931, p. 945;
Railway Signaling & Communications, January 1932, p. 13.

ROCK ISLAND. — 85 MILES EITHER WAY ON EITHER TRACK :

Railway Age, June 17, 1944, p. 1173;
Railway Signaling & Communications, April 1944, p. 198.

PENNSYLVANIA. — LONG SIDINGS ON SINGLE TRACK :

Railway Age, April 26, 1947, p. 845;
Railway Signaling & Communications, January 1947, p. 31.

C & NW. — BOTH WAYS ON EITHER TRACK :

Railway Age, April 8, 1950, p. 40;
Railway Signaling & Communications, April 1950, p. 217.

BOSTON & MAINE. — DOUBLE TO SINGLE-TRACK :

Railway Signaling & Communications, December 1950, p. 799.

MILWAUKEE. — SINGLE TRACK REPLACES DOUBLE :

Railway Age, February 26, 1951, p. 26;
Railway Signaling & Communications, April 1951, p. 233.

B & M. — CTC ON SINGLE TRACK PERMITS REMOVAL OF SECOND MAIN :

Railway Age, September 10, 1951, p. 47;
Railway Signaling & Communications, September 1951, p. 601.

ERIE. — DOUBLE TO SINGLE TRACK :

Railway Age, October 1, 1951, p. 97;
Railway Signaling & Communications, December 1951, p. 847.

SANTA FE. — 80 % NON-STOP MEETS ON SINGLE TRACK :

Railway Age, December 28, 1953, p. 55;
Railway Signaling & Communications, February 1954, p. 34.

MP — CTC INCREASES CAPACITY OF DOUBLE TRACK :

Railway Age, February 1, 1954, p. 23;
Railway Signaling & Communications, March 1954, p. 48.

SOUTHERN. — COMBINED SINGLE-TRACK AND DOUBLE-TRACK :

Railway Age, May 31, 1954, p. 40;
Railway Signaling & Communications, May 1954, p. 33.

FRISCO. — BOTH WAYS ON BOTH TRACKS :

Railway Age, January 24, 1955, p. 35;
Railway Signaling & Communications, February 1955, p. 36.

NEW BOOKS AND PUBLICATIONS.

[385 .02]

Directory of Railway Officials and Year Book, 1955-1956. — London : Tothill Press Limited, 33, Tothill Street, Westminster. S.W.1. — One volume of 536 pages ($8\ ^1/_2 \times 5\ ^1/_2$ inches). Price : 40 s. net.

The Directory of Railway Officials and Year Book, 1955-1956 reaches with the present volume its 61st year of publication.

The first edition was compiled from official sources in 1895. The present edition of 536 pages covers the text including an index to countries, an index to names of railways and the personal index to railway officials, a noteworthy feature of the volume.

This edition should prove as valuable as its predecessors. There has been no markedly changes in the layout and general arrangement, but the revision of general entries and changes in personnel are extensive.

In particular, important changes have occurred in the entries relating to the various units of the British Transport Commission. A new scheme of railway organisation came into effect on January 1 last, and Area Boards (corresponding to the respective Regions) were interposed between the Commission and the Chief Regional Managers, who were retitled General Managers.

The composition of the Area Boards is given under the respective railway Regions, but the functions of these Boards will not necessarily be confined to Railways.

As in the past, all entries continue to be divided into one of two mains divisions, namely British Commonwealth (regardless of Dominion or Colonial status) and Foreign, each of these sections is again subdivided geographically into continents and countries.

Once again, it has been impossible to secure reliable information about the railways of many of the countries of Eastern Europe and large parts of Asia.

This manual will be found of invaluable interest to all those interested in railway matters.

[385 (09 (45)]

Ingegneria Ferroviaria, Maggio-Giugno 1955. Fascicolo dedicato al Cinquantenario delle Ferrovie dello Stato. *(Ingegneria Ferroviaria, May-June, 1955. Number devoted to the Fiftieth anniversary of the State Railways).* — One volume ($8\ ^3/_4 \times 11\ ^1/_2$ in.) of 200 pages, copiously illustrated. — 1955, Roma, *Ingegneria Ferroviaria*, Piazza Croce Rossa.

It was on the 1st July 1905 that the various railways, which then operated the lines that existed in Italy, were amalgamated into a single railway under the title of the Italian State Railways. Many tragic events have severely afflicted the new undertaking during its first half century. Yet it has never failed to strive after perfecting this necessary equipment for the economic life of the country.

Senator Professor-Engineer Guido Corbellini gives in this fine special issue of *Ingegneria Ferroviaria* a short history of the *Ferrovie dello Stato* since its creation up to the present time.

First of all, there is a brief report of

the circumstances and discussions which led to the adoption of the law relating to the new regime.

The first period considered is from the setting up of the State Management to the first world war. This decade was marked by additions to the rolling stock, by pioneer electrification programmes and by important civil engineering works. The war in Libya and two earthquakes were a severe trial of the organisation of the railway services.

The second chapter, devoted to the first world war, gives a picture of the extraordinary demands which were made upon the railway staff, its devotion and the great sacrifices it accepted.

During the period between the two wars, in spite of trade union agitations and political upheavals, important technical progress was made : extensions of electric traction on the original systems, construction of new through lines. The fight against competition was organised.

The second world war submitted the Italian railways to further trials.

In the final chapter, the author recalls the vast amount of damage that was done and the rapidity with which the railway was restored to working order.

In his report the author pays tribute to the men who succeeded to the general managership and stamped their individuality upon the job.

The second part is entirely devoted to illustrations, and here the reader will see the most recent and most remarkable achievements of the F. S. in various fields : track equipment, bridges, large stations, rolling stock, electrification, signalling, institutions for the benefit of the staff. A few pages are devoted to transport across the Straits of Messina.

This work is a beautiful synthesis of the life of the F. S. from its creation to the present day. It enables us to appreciate the great efforts made before the system was brought to its present state of perfection.

E. M.

[669 .71]

Congrès International de l'Aluminium (Paris, 1954). Rapports et discussions. — *(The International Aluminium Congress (Paris, 1954). Reports and discusions.)* — Two volumes ($8\ ^{11}/_{16} \times 10\ ^{3}/_{4}$ in.) of 358 and 350 pages respectively with numerous illustrations. — 1955, Paris (8°), Société d'Édition et de Documentation des Alliages Légers, 77, Boulevard Malesherbes.

To commemorate the first industrial manufacture of aluminium, the « Société Chimique de France » and « l'Aluminium Français » organised an *International Aluminium Congress* in Paris from the 14th to the 19th June 1954.

The Congress was patronised by a Committee composed of many learned societies from France and other countries, representatives of industry, management and education.

This very brilliant meeting brought together authors of various nationalities. The number of reports presented totalled eighty-one, 33 being by foreign authors.

Before the working sessions, which lasted two and a half days, a solemn meeting was held in the Sorbonne to commemorate the centenary of the industrial manufacture of aluminium by Henri Sainte-Claire Deville.

The delegates to the Congress had the opportunity of visiting several large factories making use of aluminium. In addition during a two days educational tour, they were able to see factories at work which are noteworthy on account of their power and up-to-date equipment.

The two volumes published by the

organisers of the Congress give the complete text of the reports presented. These are grouped into seven classes under the following headings :

Class I. — Chemistry and physico-chemistry of aluminium and its compounds.

Class II. — The manufacture of aluminium.

Class III. — Methods and processes of analyses.

Class IV. — Study of aluminium and its alloys.

Class V. — Anodic oxidisation and corrosion.

Class VI. — Transformation and working techniques.

Class VII. — User techniques and fields of application.

As this list shows, the studies presented covered a very vast field comprising the manufacture of aluminium and the uses to which it is put. Each of them deals with a well defined subject and is preceded by a short résumé. A brief report of the discussions gives the observations made by specialists in the same subject. This method of working and this classification of the subject matter makes it very easy to refer to any point and makes the book very valuable.

We can join with the organisers in rejoicing at the success of this *International Aluminium Congress,* which was a great scientific and industrial occasion. Our thanks are also due to them for having published in these two fine volumes a collection of studies of very great value.

E. M.

MONTHLY BIBLIOGRAPHY OF RAILWAYS[1]

PUBLISHED UNDER THE SUPERVISION OF

P. GHILAIN,

General Secretary of the Permanent Commission of the International Railway Congress Association.

(DECEMBER 1955)

[016. 385. (02]

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In French.

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Quelques aspects du problème européen de l'énergie. Paris (16e), Organisation Européenne de Coopération Economique, 2, rue André-Pascal. Une brochure (15 × 24 cm) de 68 pages. (Prix : 300 fr. fr.)

1955 721

CAMBEFORT (H.).

Forages et sondages. Leur emploi dans les Travaux Publics.

Paris, Eyrolles, éditeur, 61, boulevard St.-Germain. Un volume (16.5 × 25 cm) de 400 pages, avec 370 figures. Prix : 3 200 fr. fr.)

1955 531

DENIS-PAPIN (M.).

Aide-Mémoire Dunod : Mécanique-Physique générale. 5e édition.

Paris, Dunod, éditeur. Un volume (10 × 15 cm) de 233 pages, avec 133 figures et 1 dépliant. (Prix : relié simili-cuir, 480 fr. fr.)

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Lignes de contact pour trolleybus.

Rapport V du XXXIe Congrès International (Naples, 1955), de l'Union Internationale des Transports Publics.

Bruxelles : Union Internationale des Transports Publics, 18 avenue de la Toison d'Or. Une brochure (21.5 × 27 cm) de 60 pages de texte, avec figures et planches hors texte.

1955 625 .6 (4)

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La situation présente et l'avenir des chemins de fer d'intérêt local en Europe. Rapport VIII du XXXIe Congrès (Naples, 1955), de l'Union Internationale des Transports Publics.

Bruxelles : Union Internationale des Transports Publics, 18, avenue de la Toison d'Or. Une brochure (21.5 × 27 cm) de 26 pages.

1955 625 .25 : 625 .62 (06

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Systèmes de freinage pour tramways. Rapport IV du XXXIe Congrès International (Naples, 1955) de l'Union Internationale des Transports Publics.

Bruxelles : Union Internationale des Transports Publics, 18, avenue de la Toison d'Or. Une brochure (21.5 × 27 cm) de 26 pages, avec figures.

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Rentabilité et moyens à envisager en vue du meilleur rendement des entreprises de transport.

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Bruxelles : Union Internationale des Transports Publics, 18, avenue de la Toison d'Or. Une brochure (21.5 × 27 cm) de 18 pages, avec figures.

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Etude et calcul des structures en alliages légers.

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Bruxelles : Union Internationale des Transports Publics, 18, avenue de la Toison d'Or. Une brochure (21.5 × 27 cm) de 16 pages, avec planches-annexes.

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Manuel du béton précontraint. (Avec un exposé généra de R. VALLETTE.)

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Berlin, Verlag von Wilhelm Ernst & Sohn. XVI-598 Seiten (davon 444 Eisenbahntechnik), 634 Bilder, 116 Tafeln, Sachverzeichnis mit etwa 1 400 Stichwörtern. (Preis, Ganzleinen : DM 56.—)

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Die Praxis des Facharbeiters und Poliers im Eisenbahn-Oberbau. 2. Auflage.

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HEIM. — **Laufleistungen und Unterhaltungskosten rasch laufender Motoren** mittlerer Leistung im Betriebe der Deutschen Bundesbahn. (3 000 Wörter & Abb.)

1955 **621** .431 .72
Glasers Annalen, Juni, S. 177.
LINDNER (E.). — **Henschel- Diesel-hydraulische Drehgestell-Lokomotive DH 875.** (2 000 Wörter & Abb.)

1955 **621** .431 .72
Glasers Annalen, Juni, S. 182.
BREDENBREUKER (F.) & FEUSTEL (H.). — **Laufwerksanordnung von dreiachsigen Diesellokomotiven mit Blindwellenantrieb.** (2 000 Wörter & Abb.)

1955 **621** .431 .72 (81)
Glasers Annalen, Juni, S. 194.
HEINRICH. — **Dreiteilige dieselhydraulische Triebwagenzüge** für Brasilien. (2 500 Wörter & Abb.)

Internationales Archiv für Verkehrswesen. (Mainz.)

1955 **656**
Int. Archiv für Verkehrswesen, Nr. 14, 2. Juliheft, S. 320.
MÖLLER (H.). — Umfang und Kosten der **Transportversicherung** bei den verschiedenen Verkehrsmitteln. (2 000 Wörter.)

1955 **385** (42)
Int. Archiv für Verkehrswesen, Nr. 15, 1. Augustheft, S. 340.
WOELKER (Ch.). — Der **Modernisierungsplan** der Britischen Eisenbahnen. (4 000 Wörter.)

1955 **656** .23
Int. Archiv. für Verkehrswesen, Nr. 16, 2. Augustheft, S. 369.
Prof. W. BÄSELER. — Um den **gemeinwirtschaftlichen Tarif.** (2 000 Wörter.)

1955 **656**
Int. Archiv. für Verkehrswesen, Nr. 17, 1. Septemberheft, S. 396.
FRICKE (H.-J.). — Das **Zusammenwirken der Verkehrsträger im Fahrplanwesen.** (1 200 Wörter.)

Der öffentliche Verkehr. (Bern.)

1955 **656**
Der öffentliche Verkehr, September, S. 5.
Die **Finanzierung der Verkehrswege.** (1 500 Wörter.)

Schweizerisches Archiv für Verkehrswissenschaft und Verkehrspolitik. (Zürich.)

1955 **385** (09 (481)
Schweizerisches Archiv für Verkehrswissenschaft und Verkehrspolitik, Nr. 3, S. 233.
PASZKOWSKI (F.). — Die **Eisenbahnpolitik Norwegens.** Zum 100-jährigen Bestehen der norwegischen Eisenbahnen. (13 000 Wörter & Karte.)

In English.

Electrical Engineering. (New York.)

1955 **656** .25
Electrical Engineering, September, p. 760.
BAUGHMAN (G.W.). — **Railway signaling.** (3 600 words & figs.)

1955 **625** .233
Electrical Engineering, September, p. 789.
BREDENBERG (E.F.). — **A new power supply for railway cars.** (600 words.)

The Engineer. (London.)

1955 **621** .131 .2
The Engineer, September 2, p. 327.
TUPLIN (W.A.). — **Loads in locomotive coupling rods.** (4 200 words & figs.)

1955 **621** .438
The Engineer, September 23, p. 455.
Mobile 5 500 kW gas-turbine-electric power plant. (4 800 words & figs.)

1955 **621** .132
The Engineer, September 30, p. 468.
COOK (K.J.). — **The steam locomotive :** a machine of precision. (5 000 words & figs.)

Engineering. (London.)

1955 **625** .141 (42)
Engineering, August 19, p. 247.
Recovery of track ballast. Cleaning plant on British Railways. (500 words & fig.)

Mechanical Engineering. (New York.)

1955 **621** .438
Mechanical Engineering, September, p. 802.
Mobile gas-turbine power plant. (2 200 words & figs.)

Modern Railroads. (Chicago.)

1955 **625** .244 (73)
Modern Railroads, September, p. 91.
New mechanical reefer. (1 500 words & figs.)

1955 **621** .431 .72 (73)
Modern Railroads, September, p. 103.
A new train is born. (1 200 words & figs.)

1955 **656** .25 (73)
Modern Railroads, September, p. 121.
Versatile train control system. (600 words & figs.)

Modern Transport. (London.)

1955 **621** .33 (42)
Modern Transport, September 10, p. 11.
Eastern Region electric traction. (1 500 words & figs.)

1955 **656** .2 (42)
Modern Transport, September 17, p. 3.
British Railways modernisation. (1 000 words & figs.)

1955 **621** .431 .72 (42)
Modern Transport, September 17, p. 17.
New power equipments for standard types. — B. R. Diesel-electric shunters. (600 words & figs.)

1955 **621** .138 .5 (42)
Modern Transport, September 24, p. 5.
COOK (K.J.). — **Precision in British Railway workshops.** Locomotive construction and maintenance. (1 600 words.)

The Oil Engine and Gas Turbine. (London.)

1955 **621** .431 .72 (42)
The Oil Engine and Gas Turbine, September, p.176.
Two-stroke sets for B.R. shunters. (1 000 words & figs.)

Railway Age. (New York.)

1955 **625** .162 (73)
Railway Age, August 8, p. 44.
How protection was improved at seven crossings. (1 200 words & figs.)

1955 **625** .617 (73)
Railway Age, August 8, p. 46.
TOFC - Helping hand for box cars. (1 000 words & figs.)

1955 **656** .25 (73)
Railway Age, August 15, p. 37.
How radio helps the Lackawanna. (1 500 words & figs.)

The Railway Gazette. (London.)

1955 **625** .234 (42)
The Railway Gazette, July 29, p. 133.
Rolling stock steam heating equipment. (1 000 words & figs.)

1955 **625** .232 (73)
The Railway Gazette, August 5, p. 157.
Passenger stock developments in U.S.A. — Lightweight articulated trains 11 ft. high, and hi-level double-deck stock 15 ft. 6 in. high. (800 words & figs.)

1955 **656** .25 (42)
The Railway Gazette, August 12, p. 189.
Speed control signalling on London Transport lines. (1 200 words & figs.)

1955 **625** .28
The Railway Gazette, August 19, p. 215; September 2, p. 281.
McARD (George W.). — **Design of locomotive and railcar frames.** I-II. (4 400 words & figs.)

1955 **625** .245 (73)
The Railway Gazette, August 19, p. 218.
Bogie type container wagons. (300 words & figs.)

1955 **625** .25
The Railway Gazette, August 26, p. 243.
A new brake system for Diesel locomotives. (800 words & figs.)

1955 **621** .335 (68)
The Railway Gazette, September 2, p. 274.
South African Railways 2 000-HP electric locomotives. (900 words & figs.)

1955 **621** .33 (42)
The Railway Gazette, September 2, p. 277.
MANN (F.A.W.). — **Overhead electrification equipment.** A review of British practice. (3 600 words & figs.)

1955 **625** .617 (94)
The Railway Gazette, September 9, p. 305.
Complete narrow-gauge trains on standard-gauge wagons. (1 200 words & figs.)

1955 **656** .25 (494)
The Railway Gazette, September 16, p. 333.
Space interval driver's vigilance device. (1 000 words & figs.)

1955 **625** .173 (52)
The Railway Gazette, September, 16, p. 335.
Track maintenance in Japan. (900 words & figs.)

Diesel Railway Traction
A Railway Gazette Publication. (London.)

1955 **621** .333 (42)
Diesel Railway Traction, September, p. 261.
Paxman YL railway oil engine. (4 500 words & figs.)

1955 **621** .431 .72 (42)
Diesel Railway Traction, September, p. 267.
More B.R. standard shunters. (800 words & figs.)

1955 **621** .431 .72 (931)
Diesel Railway Traction, September, p. 279.
750-HP locomotives for New Zealand. (1 500 words & figs.)

Railway Locomotives and Cars. (New York.)

1955 **625** .244 (73)
Railway Locomotives and Cars, September, p. 67.
EMD reefer designed for minimum maintenance. (3 600 words & figs.)

1955 **625** .244 (73)
Railway Locomotives and Cars, September, p. 77.
Army Transportation Corps shows U.S.... what **Mekydro torque converter can do.** (1 800 words & figs.)

Railway Track and Structures. (Chicago.)

1955 **625** .143 .4 (73)
Railway Track and Structures, September, p. 47.
Two new rail sections are designed for... greater stiffness, more capacity for head wear, reduced shelling. (900 words & figs.)

In Italian.

Giornale del Genio Civile. (Roma.)

1955 **624** .2
Giornale del Genio Civile, luglio-agosto, p. 467.
BIRATTARI (L.). — Sul problema delle massime e minime **sollecitazioni nelle travi appoggiate percorse da un treno di carichi.** Generalizzazione del « poligono A ». (1 000 parole & fig.)

In Netherlands.

De Ingenieur. (Den Haag.)

1955 **625** .232
De Ingenieur, nr 29, 22 Juli, p. V. 25.
De NIET (J.). — Factoren die bepalend zijn voor de **inrichting en uitvoering van spoorwegrijtuigen.** (3 000 woorden & fig.)

1955 **691**
De Ingenieur, nr 31, 5 Augustus, p. Bt. 61.
HARTMANN (J.A.H.). — Enige algemene beschouwingen over de **breukveiligheid van voorgespannen beton en de richtlijnen voor de toelaatbare spanningen.** (2 500 woorden.)

1955 **621** .13 & **625** .28
De Ingenieur, nr 32, 12 Augustus, p. V. 35.
OUDENDAL (F.). — De **bouw van locomotieven.** (3 000 woorden & fig.)

Spoor- en Tramwegen. (Den Haag.)

1955 **621** .33
Spoor- en Tramwegen, nr 15, 21 Juli, p. 225; nr 16, 4 Augustus, p. 243.
KOSTER (J.P.). — **Electrische tractie met eenphase wisselstroom 50 perioden.** (4 500 woorden & fig.)

1955 **625** .42 (45)
Spoor- en Tramwegen, nr 15, 21 Juli, p. 236.
De **ondergrondse spoorweg** te Rome. (500 woorden & fig.)

1955 **351** .757
Spoor- en Tramwegen, nr 17, 18 Augustus, p. 257.
DE POUS (K. Chr.). — De **Spoorwegrecherche.** (2 500 woorden & fig.)

1955 **656** .212 .5 (44)
Spoor- en Tramwegen, nr 18, 1 September, p. 273.
DE COCK (E.). — Inrichting en capaciteit van moderne Franse **rangeerheuvels.** (1 600 woorden & fig.)

1955 **621** .431 .72
Spoor- en Tramwegen, nr 18, 1 September, p.279.
De stoutmoedige opmars van de **Diesel.** (3 000 woorden.)

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ANALYTICAL TABLE OF ARTICLES

ARRANGED ACCORDING TO THE DECIMAL CLASSIFICATION (1955)

	Month.	Pages.
3. SOCIOLOGY IN GENERAL.		
31. STATISTICS.		
313 : 385. Railway statistics in general.		
A review of 1954 Railway Operations, by J. Elmer MONROE	July	513
313 : 656. Statistics relating to transports.		
Schweizerische Verkehrsstatistik. *(Swiss Transport Statistics.) (New Books and Publications)*	August	621
Bulletin Annuel de Statistiques de Transports, 1953 *(Annual Bulletin of Transport Statistics, 1953). (New Books and Publications)*	October	777
38. COMMERCE. COMMUNICATIONS.		
385. RAILWAYS FROM A GENERAL, ECONOMIC AND FINANCIAL POINT OF VIEW.		
Die Niederländischen Eisenbahnen als kommerzielles Unternehmen *(The Netherlands Railways as a business undertaking)*, by Dr. P. BOENDER *(New Books and Publications)*	»	774
385 (02. Railway handbooks, treatises, etc.		
Directory of Railway Officials and Year Book 1955-1956	December	910
385 (05. Periodicals.		
Jahrbuch des Eisenbahnwesens 1954 *(Railway annual 1954). (New Books and Publications)*	July	546
385 (06. Societies, associations, scientific congresses.		
385 (06 .111. International Railway Congress Association. Official documents.		
Official Information issued by the International Railway Congress Association :		
Meeting held by the Permanent Commission, in Brussels, on the 13th. November 1954. *Appendix I :* List of Members of the Permanent Commission ; *Appendix II :* List of the participating Administrations and adherent Organisations	February	146
Revision of the Rules and Regulations of the Association	»	157
List of Questions for discussion at the Enlarged Meeting of the Permanent Commission (The Hague-Scheveningen, 1956), with the names of the Reporters	April	297
List of Members of the Permanent Commission (1st June 1955)	June	465
385. (06 .112. International Railway Congress Association. Proceedings.		
I. Sixteenth Session London : 19th-26th May 1954. General Proceedings in Sections and in Plenary Meetings.		
SECTION II. — *Locomotives and Rolling Stock.* Inaugural Meeting of the 2nd Section	February	61
SECTION III. — *Working.* Inaugural Meeting of the 3rd Section	April	233

	Month.	Pages.
SECTION IV. — *General.* Inaugural Meeting of the 4th Section	June	371
SECTION V. — *Light Railways and Colonial Railways.* Inaugural Meeting of the 5th Section	July	551
385 (08. Annual reports of railway companies and administrations.		
Red Nacional de los Ferrocarriles Españoles. — Memoria del Consejo de Administración. Ejercicio 1953 *(Spanish National Railways. Report of the Management for the year 1953.) (New Books and Publications)*	»	544
Federation of Malaya. Malayan Railway Administration Report for the year 1953, by C. G. HARRISON *(New Books and Publications)*	»	544
State of Thailand. Annual Report for the year Buddhist Era 2495 *(New Books and Publications)*	»	545
Tasmania. Report of the Transport Commission on the operations, business and affairs of the Transport Department during the year ended 30th June 1953 *(New Books and Publications)*	»	545
385 (09. History, description of railways, etc.		
Uno sguardo alle attivita delle F.S. nell' anno 1954 *(A review of the activities of the Italian State Railways in the year 1954), by* Dr.-Ing. G. DI RAIMONDO *(New Books and Publications)*	October	772
Ingegneria Ferroviaria, Maggio-Giugno 1955. Fascicolo dedicato al Cinquantenario delle Ferrovie dello Stato *(Ingegneria Ferroviaria May-June 1955. Number devoted to the Fiftieth anniversary of the State Railways) (New Books and Publications)*	December	910
385 (09. 2. Obituary notices.		
Obituary : Dr. Eng. Felice FIORI	April	295
Lt. Colonel Sir ALAN MOUNT	November	847
385 (09. 3. History.		
Beiträge zur Schweizerischen Eisenbahngeschichte *(Contributions to the History of the Swiss Railways)*, by E. MATHYS *(New Books and Publications)*	July	546
Hundert Jahre Semmeringbahn *(The Centenary of the Semmering Railway) (New Books and Publications)*	»	549
Vårt Yrke. Jubileumsnummer 1854. — Hundre Ar — 1954. *(Our Profession. Jubilee Number. One hundred years, 1854-1954.) (New Books and Publications)*	August	621
World Railways 1954-55 *(New Books and Publications)*	October	776
385 .4. Internal administrative organisation of railways.		
Determination of the principles of geographical and functional organisation of a railway system. Simplification and retrenchment of the administration of railways *(Question 8 — 16th Congress) :* Discussion	June	406
385 .5. Staff.		
385 .57. Recruiting and promotion of staff.		
Modernisation of the methods to be adopted for recruiting the staff in number and qualification. Harmonious renewal of the various ranks, indispensable reserve lists, ratio of the permanent and temporary staff. Part played by the medical service in the recruiting *(Question 7 — 16th Congress.) :* Discussion	»	373

	Month.	Pages.
385 .6. International agreements relating to railways.		
Die Freiheit im Internationalen Verkehr *(Liberty in International Traffic)*, by Dr. Werner HAUSTEIN *(New Books and Publications)*	October	775
62. ENGINEERING.		
62 (03. Dictionaries, cyclopedias.		
Englishes Wöterbuch fur Eisenbahnsignalwesen und Fernmeldetechnik. English-Deutsch. Deutsch-English *(Dictionary for Signalling and the Technique of Telecommunications. English-German. German-English)*, by Dr. Ing. habil. W. SCHMITZ *(New Books and Publications)*	»	778
621. MECHANICAL AND ELECTRICAL ENGINEERING.		
621 .1. Steam engineering.		
621 .13. Locomotive engines.		
621 .13. (02 General treatises.		
La Locomotora. Manual practico para los maquinistas y fogoneros *(The Locomotive. Practical handbook for drivers and firemen)*, by U. LAMALLE and F. LEGEIN *(New Books and Publications)*	»	774
621 .131. Theory of the locomotives.		
621 .131 .2. Investigation of the conditions to be fulfilled in building a locomotive.		
Means and methods to improve the efficiency of steam locomotives : *a*) increase of steam pressure; *b*) types of grates; *c*) superheating of the steam; *d*) preheating of the feeding water; *e*) feed water treatment, etc. *(Question 4 — 16th Congress.)* : Discussion	February	111
621 .135. Vehicles.		
621 .135 .4. Lateral play on curves. Bogies. Bissell bogies.		
Wear of rails on curves : *a*) characteristics of track-laying on curve and details of the rolling stock liable to cause premature wear of the rails; *b*) running effects of locomotives and motor coaches with motor bogies; *c*) results of the investigations made and proposed remedies. Use of rail-lubrication processes *(Question 10, 16th Congress.)* : Discussion	August	553
621 .137. Locomotive working.		
621 .137 (02. Compends, outlines.		
La Locomotora. Manual practico para los maquinistas y fogoneros *(The Locomotive. Practical handbook for drivers and firemen)*, by U. LAMALLE and F. LEGEIN *(New Books and Publications)*	October	774
621 .138. Laying up and maintaining the locomotives.		
621 .138 .5. Repairing shops.		
For large Diesel facility... New concept in shop ventilation	July	541

	Month.	Pages.
621 .3. Electrical engineering.		
621 .33. Electric railways and tramways. Railway electrification.		
Technical and economic investigation of the basic characteristics of electric traction systems now in use, with a view to decide whether, and to what extent, there are relevant reasons for preferring one system to another. In particular, are there any reasons in regard to : *a*) power supply; *b*) overhead line and fixed track installations; *c*) motive power units; *d*) working and maintenance costs *(Question 3, 16th Congress) :*		
Discussion	February	63
Protection of overhead lines, substations, locomotives and motor-coaches against accidents of electric nature (excess voltage, overloads, short-circuits and lightning) *(Question 11, 16th Congress) :*		
Discussion	August	584
621 .337. Starting and controlling gear.		
Individual axle drive. — Mechanical systems used on electric locomotives and motor coaches, with an indication of the results obtained in service on railways of all kinds *(Concluded)*, by Adolphe-M. HUG	July September October	469 623 701
621 .338. Rolling stock. Passenger carriages and wagons.		
Torsion bar bogies on the Rhaetian Railway. Swing bolster sprung by transverse torsion bar	August	613
621 .4. Air, gas and oil engines.		
621 .43. Ignited-gas engines. Internal combustion engines.		
621 .431. General.		
621 .431 .7. Various applications.		
621 .431. 72. Railway traction.		
Diesel locomotives, by U. LAMALLE	March	165
Diesels and rail lubricators, by J. W. DIFFENDERFER	May	359
For large Diesel facility... New concept in shop ventilation	July	541
Diesel-hydraulic C'C' locomotive of 1 900 HP for metre gauge line, by R. SCHEFFER, W. MULLER, D. VON LASSBERG, P. HIRT and F. KUGEL	November	781
G. M. building complete high speed train	December	900
621 .436. Diesel engines.		
Diesel engines. Their industrial application *(New Books and Publications)*	October	777
621 .438. Gas turbines.		
Westinghouse gas-turbine locomotive	March	218
624. BRIDGES AND ROOFS.		
Brückenbau und Ingenieurlochbauten *(The construction of bridges and other above ground structures)*. — E.T.R. Eisenbahntechnische Rundschau. Sonderausgabe 4 *(E.T.R. Review. Special issue No. 4) (New Books and Publications)*	July	549

	Month.	Pages.
624 .63. Reinforced concrete arch bridges.		
Pre-stressed concrete bridge near Nottingham, London Midland Region	May	367
624 .9. Roofs.		
Vorlesungen über Statik der Baukonstruktionen. Tome III. *(Statics of Building Construction Course)*, by Dr.-Eng. H. MAIER-LEIBNITZ *(New Books and Publications)*	July	548
625. RAILWAY AND ROAD ENGINEERING.		
Stability of earth slopes, by J. DUBUS	November	836
625 .1. Railway engineering. Way and works.		
625 .11. Scheme for a railway.		
625 .113. Longitudinal section. Gradients. Curves.		
Methods of surveying curved tracks by means of versine diagrams, by J. CHAPPELLET	May	299
625 .12. Road bed.		
Landslides at Twyford and Sonning on the Paddington-Reading line	November	840
625 .122. Construction and consolidation of embankments.		
Coastal erosion works at Folkestone Warren	January	50
625 .14. Permanent way.		
625 .14 (01. General matters. Stresses in railway track. Calculations... etc.		
Elasticity and lateral strength of the permanent way, by R. SONNEVILLE and A. BENTOT	March	184
625 .142. Supports.		
The policy of the S.N.C.F as regards sleeper supplies, by R. LÉVI	October	765
625 .143. Rails and their fastenings.		
625 .143 .3. Wear and breaking of rails.		
Roaring rails. The corrugation of steel rails, by T. Henry TURNER	May	346
Diesels and rail lubricators, by J. W. DIFFENDERFER	»	359
Wear of rails on curves : *a*) characteristics of track-laying on curve and details of the rolling stock liable to cause premature wear of the rails; *b*) running effects of locomotives and motor coaches with motor bogies; *c*) results of the investigations made and proposed remedies. Use of rail-lubrication processes *(Question 10, 16th Congress.)* : Discussion	August	553
New rail-grinder train... takes off the rough spots	October	756
Stresses to which track equipment is subjected. Undulatory wear of rail, by P. DUBUS . .	November	822
625 .143 .4. Rail joints and fishplates.		
Stresses to which track equipment is subjected. Undulatory wear of rail, by P. DUBUS . .	»	822

	Month.	Pages.
625 .143 .5. Means of fastening rails to supports. Creeping of rails.		
Special coachscrew for railway track, by G. ZAQUINI	November	831
625 .144. Plate-laying.		
625 .144 .2. Increase in width of gauge and superelevation; laying the permanent way on curves.		
The string-lining of railway curves, by A.W.T. DANIEL	March	209
625 .144 .4. Platelaying... etc.		
Weedkilling train and portable equipment	July	538
625 .16. Equipment of minor importance and approach roads to stations		
Prefabricated footbridge at Bathgate Lower	September	697
625 .162. Fencing and level crossing gates.		
Whistle and radio control of level crossing gates. Installations on important connecting railway lines in the East and South of U.S.A.	August	618
625 .17. Permanent way. Maintenance and renewal.		
Mechanised relaying on single lines	January	57
625 .172. Current maintenance.		
Weedkilling train and portable equipment	July	538
625 .18. Stores. Permanent way materials. Accounts.		
The policy of the S.N.C.F. as regards sleeper supplies, by R. LÉVI	October	765
625 .2. Railway rolling stock.		
625 .21. Parts of the vehicle.		
625 .212. Axles. Wheels. Tyres.		
Contribution to the detection of axle flaws by the ultrasonics method, by E. MEYER . .	December	851
625 .213. Suspension. Bearing springs.		
Rubber suspension for bogies	March	228
625 .214. Axleboxes and axle-guards. Lubricants.		
Roller bearings fitted to the rolling stock of the Italian State Railways and their behaviour in service, by T. BOCCONI and G. CONTI	January	1
625 .215. Bogies and Bissell bogies. Radical and convergent axles.		
Wear of rails on curves : *a*) characteristics of track-laying on curve and details of the rolling stock liable to cause premature wear of the rails; *b*) running effects of locomotives and motor coaches with motor bogies; *c*) results of the investigations made and proposed remedies. Use of rail-lubrication processes *(Question 10, 16th Congress.)* : Discussion	August	553

	Month.	Pages.
625 .216. Buffers and couplings.		
Buffer shock, by Dr.-Ing. E. h. Ernst KREISSIG	September	683
The eccentric thrust of the buffer, by Dr. Ing. E. h. Ernst KREISSIG	»	689
625 .23. Passenger carriages.		
625 .232. Carriages of express trains. Corridor carriages.		
The « Talgo » and its operation, by R. MAZARRASA	January	29
625 .233. Lighting.		
The latest electric heating and electric heating control devices applied by the Belgian National Railways, by E. MEYER	August	600
625 .236. Cleaning.		
Cleaning the exteriors of rolling stock on underground service, by A. W. MANSER . . .	May	341
625 .24. Goods wagons.		
625 .245. Special wagons.		
New ore hopper in light alloys for the transport of coal	August	616
625 .26. Carriage and wagon repairing shops.		
Modern shop for heavy car repairs. The Baltimore and Ohio stepped up freight car repairs about 50 percent by moving work indoors at Du Bois, by Ch. W. BEHRENS	October	746
625 .28. Railway rolling stock in general.		
Dieselfahrzeuge im Schienenverkehr. Eine vergleichende Betrachtung gegenüber Dampf- und elektrischer Zugförderung. *(Diesel vehicles in railway traffic. Comparison with steam and electric traction.)* Report by the Labour Community « Diesel transport on rail » *(New Books and Publications)*	August	620
International Days on Railway Traction (Liège, April 1953)	December	861
The problems of the changing of traction structure, by Dipl.-Ing. F. FLEMMING . . .	»	880
Passenger stock developments in U.S.A.	»	896
G.M. building complete high speed train	»	900
625 .4. Elevated and underground roads.		
Cleaning the exteriors of rolling stock on underground service, by A.W. MANSER . .	May	341
625 .42. Underground railways.		
La Ferrovia Metropolitana a Roma *(The Rome Metropolitan Railway)*, by Dr.-Ing. Vito PERRONE *(New Books and Publications)*	October	773

	Month.	Pages.
656. TRANSPORTATION. RAILROADING, etc.		
656. (02. Compends, outlines.		
L'exploitation commerciale des Chemins de fer français *(The commercial operation of the French Railways)*, by R. BOURGEOIS *(New Books and Publications)*	November	849
656 .1. Carriage by road.		
Railway participation in road transport undertakings *(Question 9, 16th Congress.)* : Discussion	June	435
Connecting road services at Caen, by P. BOUTIN	December	891
656 .2. Carriage by railway. Railway working.		
The S.N.C.F. is reducing the number of double lines on its system, by M. MARCHAND	July	502
A review of 1954 Railway Operations, by J. Elmer MONROE	»	513
A full programme for South African Railways. Expression of confidence in rail transport, by D.H.C. DU PLESSIS	August	607
656 .21. Station working.		
656 .211. Passenger station arrangements.		
656 .211 .5. Details of passenger stations.		
The Central Enquiry Office of the Austrian Federal Railways in Vienna, by M. J. FRISCHAUF.	September	658
Connecting road services at Caen, by P. BOUTIN	December	891
656 .212. Goods station arrangements.		
Industrial television for U.S.A. marshalling yars	March	225
656 .212 .5. Marshalling lines.		
Electronic equipment in U.S.A. marshalling yard. Radar operated speed indicator and automatic calculator	October	754
656 .22. Trains.		
656 .222. Running of trains.		
Revision of the operating conditions on the lines of average importance of the South-Eastern Region in order to speed up the fast trains, by Stéphane MERMIER.	December	865
656 .25. Safety measures. Signals.		
Englishes Wörterbuch fur Eisenbahnsignalwesen und Fernmeldetechnik. English-Deutsch. Deutsch-English *(Dictionary for Signalling and the Technique of Telecommunications. English-German. German-English)*, by Dr. Ing. habil. W. SCHMITZ *(New Books and Publications)*	October	778

	Month.	Pages.
656 .254. Apparatus for communicating information at long distances, etc.		
Automatic train announcer at Stratford Station, Eastern Region	January	59
Industrial television for U.S.A. marshalling yard	March	225
Radiophonic communications in railway working *(Question 5, 16th Congress.)* : Discussion	April	236
New radio-communication installations on the Spanish National Railways, by LERIN GRONDONA	May	328
More efficient railroading... Modern signaling = Fewer tracks, by John H. DUNN	December	904
656 .257. Combined working of signals and points. Direct interlocking.		
A) Remote operation of signal boxes : technical realizations, working orders. B) Electric working and control devices for hinged and « flexible » points and switches. Control of accidental trailing of the switch blade. *(Question 6, 16th Congress.)* : Discussion	April	267
656 .28. Accidents.		
Report to the Minister of Transport and Civil Aviation upon the Accidents which occurred on the Railways of Great Britain during the year 1953, by Lt-Col. G.R.S. WILSON *(New Books and Publications)*	July	547
66. CHEMICAL TECHNOLOGY.		
669. METALLURGY.		
669 .71. Aluminium.		
Congrès International de l'Aluminium, Paris 1954 *(The International Aluminium Congress, Paris 1954. Reports and discussions) (New Books and Publications)*	December	911
72. ARCHITECTURE.		
721. ARCHITECTURAL CONSTRUCTION.		
Vorlesungen über Statik der Baukonstruktionen. Tome III. *(Statics of Building Coustruction Course)*, by Dr.-Eng. H. MAIER-LEIBNITZ *(New Books and Publications)*	July	548

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